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AUTHOR James, Edwyn
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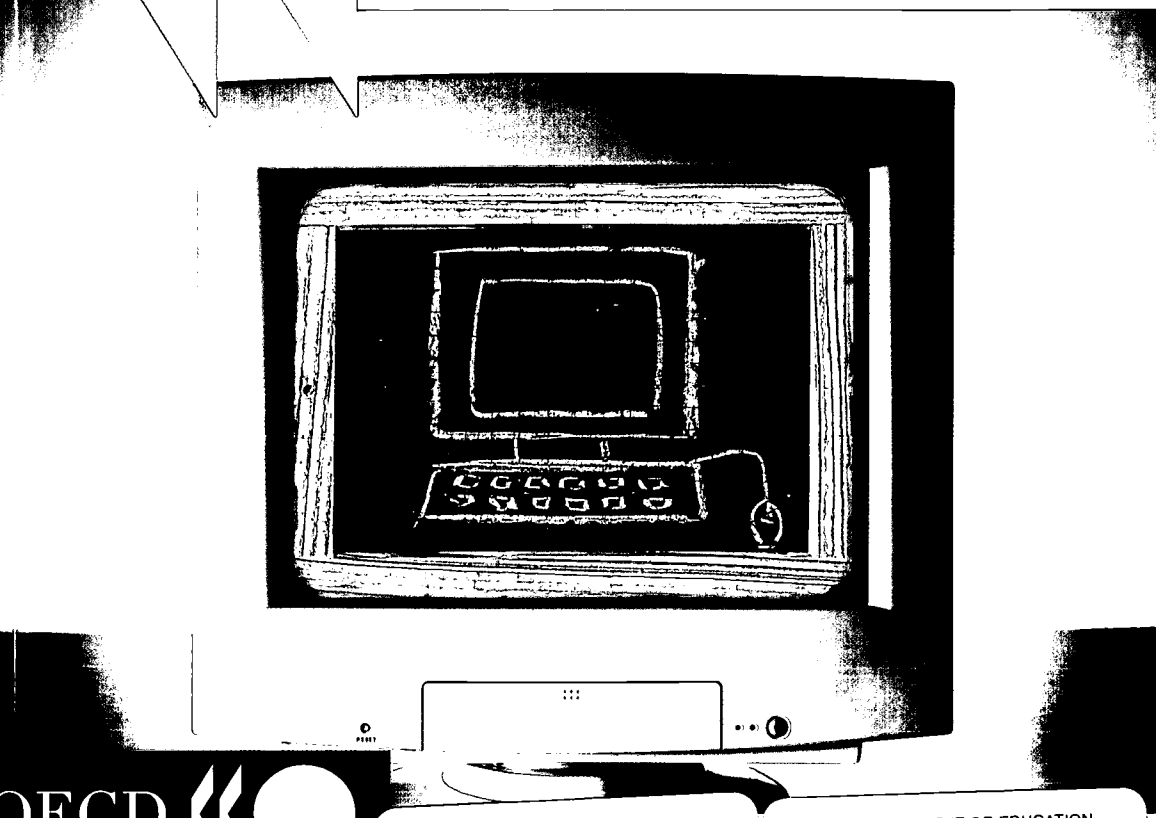
ABSTRACT

There is an urgent need for quality software and digital materials for use in schools. Teachers and students must become discerning and knowledgeable information and communication technology (ICT) users. The school environment has to be fully supportive of ICT, making available expert assistance and advice to the teacher in this rapidly changing field. New forms of curriculum and assessment are called for, new ways of organizing schools, if the dramatic educational potential of ICT is to be delivered and realized. Such a demanding "learning to change" agenda is the subject of this international report. It is illuminated by the views of individual students, who used ICT enthusiastically in their own learning, and shared their experiences in an Organization for Economic Co-operation and Development (OECD) international network. The report looks at the vast educational possibilities arising from the Internet, bringing together the school, the home and the wider community. It examines how ICT, which is the subject of teacher professional development, can largely be the means for its delivery. There are numerous examples of promising practice and principles for the future. Chapters are: "Policy Priorities for ICT in Schools"; "The Curriculum and the Learner"; "Educational Software and Digital Content"; "Schools and the Internet-Meeting the Challenge"; "The Practice and Professional Development of Teachers"; "Schools Organized for ICT and the Homes They Serve"; and "Looking to the Future." (Contains 70 references.) (AEF)

SCHOOLING FOR TOMORROW

Learning to Change: ICT in Schools

EDUCATION AND SKILLS



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Learning to Change: ICT in Schools

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APPRENDRE A CHANGER

FOREWORD

The CERI project "Information and Communication Technology (ICT) and the Quality of Learning" was launched at an International Seminar at OECD in June 1998, with the participation of 25 Member countries. It was a direct response to the interest in this topic that OECD Education Ministers had developed over the previous two years (and which has since been re-iterated). Within the project, an area of work developed in relation to the use of ICT in schools, to consider what makes for quality in the ICT-based learning experience. The present book is the outcome of that work. It is to be seen as a companion volume to *Learning to Bridge the Digital Divide* (OECD, 2000), which arose from the same CERI project. The analysis of markets and partnerships in this project has also produced the publication *E-Learning – The Partnership Challenge* (OECD, 2001*b*). Further reports will be published in 2002 on the impact on ICT on innovative schools and on student learning.

A working group was selected to be representative of policy making, teaching, academia, and the software industry. Meetings involving most of the Members were held in April 1999 (OECD), October 1999 (The Hague), and May 2000 (Budapest). Papers were prepared by group members and others, to compare national experiences and to look initially at issues of software quality criteria and the purposes they served.[1] The emphasis was on cross-curricular principles rather than subject-specific issues. As the work developed, it became apparent

1. They can be found on *http://bert.eds.udel.edu/oecd/quality/papers/papersframe.html.*

that the concept of quality had to be understood more comprehensively. It was not simply properties intrinsic to the software materials themselves, but how those materials were used. Ultimately, this had to do with school organisation and leadership, the levels of resourcing, the quality of the teaching, the nature of the curriculum and patterns of student assessment.

At a second international seminar in February 2000 (Poitiers), a country questionnaire was discussed, designed to elicit information on: the effects of ICT on the school curriculum; teachers, headteachers and their professional development; software evaluation and development; and educational use of the Internet. Subsequently, 16 Member countries responded, and others provided related information. These responses (shown as country notes in the bibliography) formed a major resource for this present report. A further resource was provided by an international network of students organised by OECD, one from each Member country (with one exception). The students exchanged views electronically during 2000, and met at the end of the year in Aix-en-Provence.[2] They provide a refreshing and perceptive user-perspective. The concluding chapter of this report includes an address given to Education Ministers, meeting at OECD in April 2001, by Professor Seymour Papert, of the Media Laboratory, Massachusetts Institute of Technology, US.

Those who assisted the Secretariat in the working group are shown on the acknowledgements page, but some must be mentioned in particular. The student network was the inspiration of Pierre Duguet, who was largely responsible for managing it and reporting on it. Angela McFarlane made important critical contributions to the preparation of the report at various stages, drawing on her very considerable experience in this field. The initial drafting of several of the chapters in the report was undertaken by Aidan Mulkeen and Robin Ritzema. These four took part in a final revision meeting at the end of April 2001. Within the Secretariat, David Istance provided strategic and critical support throughout; the report was written and prepared by Edwyn James. The book is published on the responsibility of the Secretary-General of the OECD.

2. See "School Technology through the Eyes of its Users", Report on the Aix-en-Provence Roundtable, *http://bert.eds.udel.edu/oecd/roundtables/roundtablesframe.html.*

ACKNOWLEDGEMENTS

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In addition, special thanks are due to those who made the arrangements for and hosted two of the working meetings: the Dutch Ministry of Education, Culture and Science and Ferry de Rijcke – October 25-26 1999, The Hague, the Netherlands; Professor Péter Tasnády, Vice Dean, Faculty of Sciences, Eötvös Loránd University, and Andrea Kàrpàti, Ministry of Education – May 17-20 2000, Budapest, Hungary.

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CHAPTER 1

POLICY PRIORITIES FOR ICT IN SCHOOLS

The ubiquitous presence and utility of ICT in modern life are having a significant impact on the way we live, and even on the notion of an educated person. It has led to the concept of the knowledge society – sometimes also called the learning society or information society. There is a widespread awareness that these developments have profound implications for education, and that schools must change, but as yet little detailed consideration of the extent of the change needed and the advantages that ICT can bring. The growth of the knowledge society and the pervasiveness of the technology represent a major challenge *and* a major opportunity for education.

All countries wish to enhance the quality and effectiveness of the learning process in schools, and are looking to ICT as the means whereby this may be achieved. Huge investments are now being made to equip schools with ICT. Governments want to know the conditions to be satisfied for this to lead to improvements in student attainment. In a fast-changing environment, they are often searching for the best way forward, and anxious to learn from the experience of others. This chapter considers the rationale for schools to adopt ICT, and goes on to discuss the notion of quality in the ICT-based learning environment. It concludes with a set of policy imperatives, for quality in learning to be secured. These recommendations are exemplified and fully supported in the chapters which follow.

WHY SCHOOLS HAVE TO ADOPT ICT

In at least three important respects, the dramatic changes in education implied or already brought about by ICT differ from any previous reform. First, earlier curriculum reforms arose *within* education, as educators attempted to put their own house in order. ICT has arisen *outside* the world of education, but with an irresistible case for adoption within schools. Secondly, and remarkably, it often happens that those who are taught are more comfortable with the new developments than their teachers. Finally, the pervasive nature of ICT has profound implications across the ethos and organisation of the whole of the learning environment.

We can distinguish three main rationales for the inclusion of ICT in education: the economic, the social and the pedagogical. There is some overlap between these approaches, but they can imply different emphases for the way that ICT is introduced and used in schools. For the *economic rationale* the focus is on the perceived needs of the economy – present and future – and the requirement in many areas of employment to have personnel with ICT skills. Knowledge of and familiarity with ICT is an important aspect of employability as the 21st century unfolds. There is a widespread expectation on the global scale that those nations successfully embracing the information age will benefit economically. Awareness of this economic dimension may encourage learners generally to acquire such skills, and some to take ICT as an additional optional subject leading to a vocational specialism, including the study of computer science in further or higher education.

The *social rationale* focuses on facility with ICT becoming a prerequisite for participation in society and the workplace. Competence with ICT is seen as an essential "life skill" in the same way as literacy and numeracy, so much so that the range of skills and processes supported by ICT is brought together in the notion of digital literacy, which becomes both a *requirement* and a *right* for all learners. It is therefore important to find ways to compensate those with limited access to computers outside school. Societies will suffer if some of their members have little or no facility with ICT, especially since public and other services are increasingly becoming available on-line. As usage of ICT becomes more extensive across society, wider benefits will also flow – better links between home and school, greater parental involvement in student progress, and greater scope for schools and other educational institutions to play an inter-active part in community life and development.

Thirdly, the *pedagogical rationale* concentrates on the role of ICT in teaching and learning. The potential for this has developed rapidly and dramatically with advances in ICT, from the early "drill-and-practice" programmes, and limited use in a small number of subjects. ICT can increase the breadth and richness of learning, not least through the topicality and realism that the new resources can bring. It can support the development of higher-order thinking skills, including analysis and synthesis. Students in the OECD international network found the pervasive use of ICT in schools to be motivating: they wanted schools to reflect – and provide a suitable preparation for – the realities that they recognised in contemporary life. Where this was not the case, they become increasingly disaffected with what school could offer.

There is a growing convergence between the economic, social and pedagogical rationales, since the digital literacy acquired and developed through the educational use of ICT is explicitly needed in the work and leisure of contemporary life. Between them these three rationales make a compelling case for education to take full advantage of the benefits offered by ICT. Modern society is increasingly looking to schools to foster independent and creative thinkers who can confidently solve problems and manage their own learning throughout their lives, the very qualities which ICT supremely is able to promote.

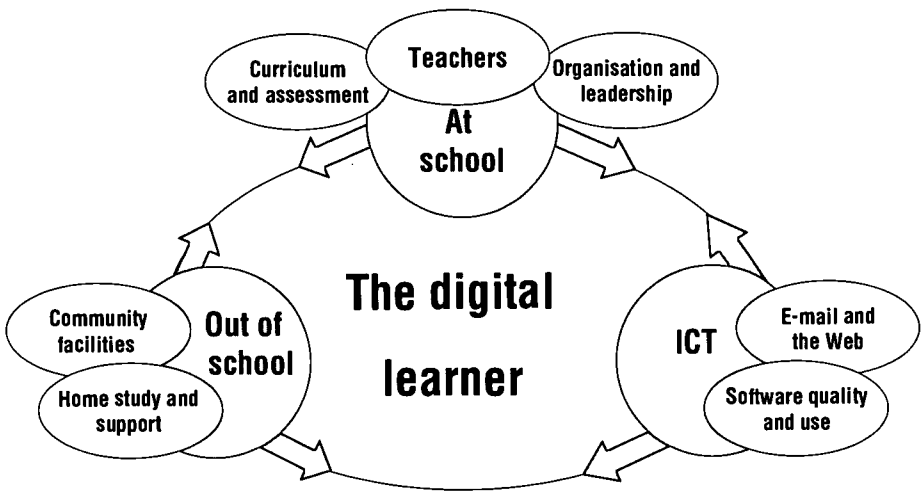
THE ISSUES TO BE ADDRESSED IN THIS REPORT

Once governments have decided to equip schools with ICT, interest moves towards establishing the conditions under which quality outcomes can be achieved. It is not a matter of simply using the technology, but of how it is used and for what purposes. The report draws on information from many OECD countries, and from the views of the students who formed an international OECD network to share personal experiences of their own use of ICT in school. It becomes apparent that many factors have to be considered in the search for enhanced quality in learning. What those factors are is the substance of the succeeding chapters of this report. They are introduced in summary form in the diagram below, which shows the major influences that impinge on the ICT-enriched learning environment of an individual school student, the *digital learner.*

The focus in the diagram is deliberately learner-centred, and takes account of the three major domains which together determine the totality of the learning experience of the student – life in school and life out of school, pervaded both by the resources and communication mechanisms of ICT. This is not to suppose that

learning is restricted to the use of ICT, but that powerful new links and opportunities are provided by this means. It is these that are considered in this report.

In spite of the expectations of some, that ICT would diminish the importance of the teacher, and even of the school, the reality appears otherwise. The school remains a central feature for the learner, and it is the teacher who remains the main point of contact. There is within school, however, a need for organisational changes and a different role for the teacher, through the integration of ICT.



How are dramatic changes on the necessary scale to be achieved? Some countries are making particular provision for school principals to receive professional development, since it is they who must determine the strategy for ICT to be successfully implemented. They are also making provision for technical and pedagogical support mechanisms by a variety of means. A novel possibility is to employ students who have technical expertise, on a part-time basis out-of-hours.

Many governments have recognised the need for pre-service and in-service professional development for teachers, to equip them with the technical skills for using ICT, and to know how to incorporate it effectively into their teaching. Increasingly, ICT is being introduced into initial teacher education, although having to compete for space with other priorities. The report illustrates several approaches for serving teachers, who more-and-more are using electronic networking to extend their professional competence. The well-networked teacher, engaged in such continuous professional exchange and development with

colleagues, will become for the student an exemplary role model of lifelong learning. Should time be found for such networking and other extensions to professional activity as a contractual right and obligation? How are the costs of providing adequate development and enhanced professionalism for teachers to be met?

There is a general trend towards adoption of ICT across all subjects, to enrich the learning environment. In the first instance ICT may simply provide an alternative delivery medium, as when an encyclopaedia is stored on CD-ROM, or writing is done using a word-processor. This offers some gains to the learner, but schools have also developed more novel ways of using ICT, as the report indicates, with illustrations from the experience of the students in the OECD network. Students are seen judging the relevance of an activity to the task in hand, assessing quality and reliability, working constructively in a team, and deploying materials in ways that add value and support the learning process.

How are schools to move to a greater emphasis on these new opportunities supported by ICT? Because such skills and processes are not customarily tested through orthodox examining methods, they appear under-valued in traditional curricular approaches. Is it not increasingly incongruous to limit student assessment to what can be measured by traditional hand-written examinations? Several countries are experimenting with ICT-based examining techniques; as ICT becomes a pervasive influence and working medium for teaching and learning in schools, then it should come to enjoy a corresponding importance in their assessment procedures. There is renewed interest also in formative assessment – regular informal updating of student progress and difficulties – since ICT offers promising avenues for rapid diagnostic feedback, to refine learning and teaching strategies.

Schools use a wide range of software and digital content, much of which was not specifically developed for education. Judgements of quality depend on the use to which the materials are put as well as the properties intrinsic to the materials themselves. Many evaluation schemes have moved from fixed standards to be met to application of open and flexible guidelines, in view of the growing number of materials and range of use. There is a critical role for teachers in the ICT evaluation process, and gaining such proficiency is an important aspect of professional development. Increasingly ICT-based materials used in teaching and learning will be partly commercially developed, partly produced by the teachers and learners themselves.

As an abundant source of information and means of communication, the Internet opens up unparalleled possibilities for learners and teachers. Given the

fluidity of Internet use, including learners generating content as they interact with each other, the focus for quality evaluation of Web-based resources shifts towards empowering students and teachers to make their own discriminating judgements. This shift is a marked departure from earlier forms of purportedly objective software evaluation, and leads to the concept of an "Internet learning style" – interactive, search-oriented, collaborative, but with individual autonomy. Educational portals select and classify educational materials to enable purposeful searching. It becomes impractical for them to offer independent evaluations, but some incorporate feedback from users and descriptions of actual classroom use, which adds to their value to teachers and students. How is such feedback to be stimulated on a larger scale?

This report illustrates that ICT has established a new complementarity between formal learning in school and informal learning outside. The critical relationships between home and school – that stimulate quality learning when they work well – become more important with the advent of ICT. Traditionally school work has been supplemented by homework, but homework that was very much seen as a reinforcement of formal school activity. Other learning that took place out of school attracted little attention within the formal curriculum and was largely discounted. ICT has added enormously to the possible strategies for learning *out* of school, in support and extension of learning *in* school, at a minimum when students can use CD-ROMs at home, but especially when there is ready home access to the Internet.

Out-of-hours, students access school Web sites and others of their own choosing, sometimes interactively. They learn by e-mail communication with their peers in a mutually stimulating and supportive fashion. Dialogue arises more easily and more meaningfully between schools and homes via Web pages and e-mail, promoting greater understanding between them, as the learner, the teacher and the parents establish an identity of purpose. What can be done to make effective partnerships between parents, students and teachers more normal? Some homes have little or no ICT resources, however, or cannot afford extended on-line activity. To what extent can low-cost public facilities with easy user-friendly access compensate in such cases?

These are the themes and concerns summarised in the diagram and dealt with more fully in the report. The diagram intentionally emphasises the inter-dependence among the different elements, since a vibrant and effective learning environment must simultaneously take account of each. It is the intention of the report to indicate how the adoption of ICT has the potential to enrich the

learning environment in hitherto unimaginable ways, and to establish the conditions under which these gains can be delivered. The main policy concerns identified below have been distilled from the various chapters. They are presented as a summary of important issues to be addressed, and problems to be resolved. Each is amplified and illustrated in the pages that follow. Quality in the ICT-enhanced learning environment requires attention to them all.

DIRECTIONS FOR POLICY

Radical curriculum change is needed in the Internet age

Powerful tensions exist between traditional curricula – based on well-defined content and rules for students to learn and be able to reproduce – and the open, skills-based, student-centred approaches supported by ICT. Dominant curricular and organisational patterns in school were not designed for the Internet age, and often inhibit its effective use. ICT offers some gains for traditional curriculum delivery, but its full educational potential cannot be realised without radical changes in school structures and methodologies. As ICT gains acceptance in schools, it may become both the driver and the facilitator of the necessary curriculum change.

Student assessment must be compatible with ICT-enriched learning

The promotion of advanced skills and competences will fall short in assessment regimes that are overwhelmingly based on achievement in single subjects, by means of conventional written examinations. What is assessed in schools and how the assessment is performed exercises a tenacious influence on the delivered curriculum. To continue with existing patterns of student assessment will act as a brake on the imaginative use of ICT. The pervasive adoption of ICT not only *requires* different assessment procedures but *provides* a variety of means.

Digital literacy is now a fundamental learning objective for all

Just as "conventional" literacy is more than basic ability to read a sequence of words, digital literacy is more than ability to use a computer in simple ways, and both are fundamentally important. It implies a sophisticated set of competences pervading workplace, community and social life, including information-handling skills, and the capacity to make judgements about relevance and reliability when searching on the Internet. Digital literacy is a vital part of the foundations for lifelong learning and must have a high priority within the curriculum.

Schools must be fully equipped and supported for using ICT

Effective use of the technology requires suitable levels of equipment, for use on demand within each classroom, and readily available to students out of lesson time. Internet access has increased dramatically, but more work stations and higher bandwidth are needed, to promote extended and sophisticated use. Exceptional grants for the initial installation of ICT have to be followed by regular funding for maintenance, technical support, and the cost of being on-line – that can be a severe deterrent to Internet use. An on-going re-equipment programme will be needed over time to sustain quality use.

Schools need plentiful educational software of quality and easily-accessed information on it

Teachers need a comprehensive supply of quality educational software to be readily available, with easily-accessed on-line information about it, concerning subject coverage, intellectual level and ease of use. It is particularly informative to include judgements by teachers on actual classroom use. Sustained dialogue is needed between ICT suppliers and the education service, including teachers, to improve the range of software and digital content. Often it will be for governments to promote such dialogue and share some of the risks of new development.

ICT in schools requires an extended professional role for teachers

Teachers face a more demanding professional role as managers of the ICT-enhanced learning environment. They must have a range of technical and pedagogical skills, with continuous up-dating to match advances in the technology and modes of use. Much will be achieved through electronic networking with colleagues in other schools, universities and elsewhere, ICT becoming both the object of professional growth and the medium through which it is achieved. Without adequate investment in teacher professional development and enhanced professional activities, effective technology integration into schools cannot succeed.

School leadership and management must be fully committed to adopting ICT

Visionary school leadership is needed to bring about and sustain the dramatic changes enabled by ICT, to persuade and give confidence to all involved – teachers and learners, parents and others in the school and community. The school must be re-organised so that working with ICT becomes integral and unexceptional, with a move away from the traditional individualistic and isolated modes of teaching, and emphasis on digital literacy for all. Schools are often resistant to

radical change, but ICT could be a "Trojan Horse" – the means through which change is delivered being also the way that resistance is overcome.

School, home and community have new opportunities for partnership

ICT encourages – and ultimately requires – a rapprochement between formal education and the learning that takes place outside school. It brings impressive channels of communication between students, teachers, parents and the wider community, that must be purposefully developed and actively sustained. The most effective learning environment is one based on a dynamic partnership between home and school, formal and informal, teacher and taught. This underscores the seriousness of the situation for students who have inadequate home facilities, who are on the wrong side of the "digital divide".

CHAPTER 2

THE CURRICULUM AND THE LEARNER

Just as computer technology has proved a powerful tool in re-engineering many areas of human endeavour, it has the potential to transform the processes of learning and teaching. Moreover, as information-rich technology diffuses pervasively into homes and workplaces, it increasingly calls into question the relevance of much within traditional knowledge-based curricula. In a world with easy access to huge stores of information, the skills of accessing, handling and using data and materials become more important than the ability to recall in detail ever greater amounts across many fields of knowledge. The young people who inhabit this technology-rich information society already question the relevance of the traditional approach. Aspects of existing school practice are called into question, as ICT both underlines a *need* for curriculum change and affords the *means* whereby the desired change can be achieved.

ICT can provide a resource-rich environment and a learner-centred approach that together alter the teaching-learning relationship by significant dimensions. It supports different ways of learning, thinking and working across the curriculum, that enable diverse, creative and engaging forms of participation. School learners have already begun to anticipate the enormous gains, and to see the *necessity* for ICT skills, the tools they know they must have as adults in tomorrow's economy

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and society. The point was well grasped by a participant in the International Student Network:

> You can more easily find a job after graduating, if you are well skilled for the requirements of today's world. For example, my region had been a coal-mining area for a long time, but now there is much unemployment because of pit closures. To enable people there to get other jobs a special computer centre has been created in my city (...). People learn there how to operate computers and use the Internet – everything that ICT can offer in today's world. Many have already found new jobs thanks to that and unemployment has decreased immensely (...). It is the same with young graduates: many are unemployed but would get a job if they had better ICT skills.
>
> Participant in OECD International Student Network

POLICY APPROACHES TOWARDS ICT IN THE CURRICULUM

In recognition of its profound and underlying importance, many governments have adopted large programmes to introduce ICT into the school curriculum. Thus, in April 1999, the Australian State/Territory and Commonwealth Ministers of Education identified familiarity and competence with ICT as one of the central goals of education for the 21st century. Students leaving school are to understand the impact of ICT on society and be "confident, creative and productive users" (Australia, 2000*a*). Other objectives stated in the same declaration are readily attainable through ICT, including: capacity for, and skills in, analysis and problem solving; ability to communicate ideas and to collaborate with others; employment-related skills and positive attitudes towards lifelong learning. Overall, the aim is that schooling should develop fully the talents and capacities of all students.

The US government has a range of educational policies for ICT use in the 21st century, in recognition that it "offers students experiences available nowhere else".[1] The benefits identified – including computer-generated simulations – arise from using videodiscs, the Internet, and CD-ROM. Students are seen to learn problem-solving skills better than by traditional methods; they become competent in organising complex information, recognising patterns, drawing inferences and communicating findings. With similar awareness, the European Union has

1. See *http://www.ed.gov/Technology/Plan/NatTechPlan/benefits.html.*

embarked on the *eEurope 2002* plan, which will seek to ensure that all students are digitally literate by the time they leave school. In June 2000 the European Council requested (the Lisbon Declaration) that:

- Every citizen be equipped with the skills needed to live and work in the new information society.
- Member states ensure that all schools in the Union have access to the Internet and multimedia resources by the end of 2001.
- Member states ensure that all the teachers needed are skilled in the use of the Internet and multimedia resources by the end of 2002.
- Schools are progressively linked to the very high-speed trans-European network for electronic scientific communications to be created by the end of 2001.
- Europe's education and training systems must adapt to the knowledge society.

http://europa.eu.int/comm/information_society/eeurope

A variety of arrangements is now in place across OECD countries to promote ICT in schools. Often the new technologies first entered the curriculum within certain subjects, such as mathematics and physics, *e.g.* Portugal (country note), humanities, *e.g.* Canada (country note), and particularly in areas that quickly established a strong affinity with ICT, notably design technology and business studies. France began educational use of ICT with the scientific subjects – using measuring devices and spread sheets – and with language laboratories, but in line with national curriculum development, use is now growing across all subjects at all levels (country note). In the Netherlands, ICT is introduced as a subject in its own right – Dutch students learn the basics in *Information and Computer Literacy* – and then used in various other subjects (country note). A *cross-curricular* usage was adopted in the Belgian Flemish Community (country note), where minimum competencies in the use of ICT are specified by attainment targets.

Several OECD countries have defined levels of ICT usage, focussed usually on the skills of information handling and the higher-order thinking skills. The UK national curriculum has a requirement that all students be given opportunities to apply and develop their ICT capability, through the use of ICT tools to support their learning in all subjects (with the exception of physical education in the early stages). They are to use ICT to extend and refine their ideas, selecting and synthesising information from a variety of sources, with an eye to its reliability; they are to communicate electronically and reflect critically on their work as it develops (UK, country note). Even though a country may have no formal

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curriculum requirement, there is an increasing tendency for schools to include ICT within the teaching programme.

In addition to basic provision for all, ICT may be an optional subject for older students wishing to specialise, as in Canada (country note) and Denmark (country note). Education systems are not homogenous, and there are differences within systems as well as between them. Luxembourg, for instance, has ICT treated differently in different types of schools. However, the general trend is towards cross-curricular adoption of ICT, supported by studies indicating significant learning gains associated with its use. In the UK it is reported that primary schools with good ICT resources have achieved more by the end of primary education than others; the great majority (86%) of head teachers in the better-equipped schools believe ICT to have been important in raising standards (BECTA, 2001).

As with curriculum issues more generally, there may be problems in securing continuity with ICT across the different phases of education, notably the transition from primary to secondary. Increasingly, however, basic ICT capability will be acquired at the primary level and available for use and development thereafter.

- *Many governments have adopted major programmes to promote the use of ICT across all aspects of school life. This is in response to its pervasiveness in economic and social life, and to profit from its potential to improve the quality of learning through the development of higher-order competencies. It still needs to be asked how far the realities of educational practices match the ambitious official aims.*
- *The intensive use of ICT in education often began in specific subject areas, including informatics – and which areas differed to some extent across countries – but the general trend is now towards adoption of ICT across all parts of the curriculum.*
- *ICT integration across the curriculum is not incompatible with informatics as an option for some, and supplementary occasional courses on digital literacy for all.*

ICT BRINGS NEW DEPTHS TO LEARNING

The students in the International Student Network can be very perceptive in commenting on their own learning experiences involving ICT. They often give us salutary reminders of the realities behind the laudable aspirations, and

have a keen awareness of why some learning situations are successful and others not. In the experience of the student users of ICT, tools – word processing, spread sheets and graphics – were used across most subjects, along with CD-ROMs for a variety of purposes, whether subject-specific or encyclopaedic. Whatever the subject area, the small physical size and large capacity of CD-ROMs make them very appealing to students:

> CD-ROMs are easily portable, which allows students to carry numerous CDs with them during the school day, whereas if they had to carry books their load would be considerably heavier. Because CD-ROMs hold a large quantity of information, they are more convenient than books. Any written texts may run to several editions or volumes, making it time consuming and tedious when trying to find relevant information.
>
> Participant in OECD International Student Network

Interactive encyclopaedias were generally seen as effective in class, and user-friendly, even for those with little ICT experience. They allowed the student to explore without the need for constant intervention by the teacher. A recurring criticism, however, was the lack of depth in the presentation, and from an international perspective, the inequitable treatment of different world regions. An encyclopaedia would offer more information about the United States and certain European countries than the rest of the world. In particular, information about African countries was limited to brief summaries and chronologies. One student was shrewd enough to observe that the depth of treatment is no doubt related to the potential customer base in the countries concerned.

What are the advantages of CD-ROMs for learning in the different curriculum areas, as seen by the students? The illustrations which follow are drawn from particular subjects of study but are not unique to them. Students welcomed the greater reality brought to *history*, by seeing press cuttings, film of important national events including speeches, animated simulations of marches and wars, or visits to archaeological sites. A disc is *compact*, and yet affords a cornucopia of well-presented information, for instance concerning an earlier civilisation's social, political and economic organisation as well as aspects of its culture, art and religion. It makes an enjoyable way to study and to learn, or – as one student conceded – a way that is not so boring. In *geography*, the multi-media approach with a world atlas was seen to give a better understanding of

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political situations. Because of clear explanations of technical terms on a CD-ROM, the teacher has to spend less attention to defining them for students, thus making needed time available for other priorities.

In *science* and *mathematics*, students saw advantage in illustrating basic physical concepts by animation, and doing virtual experiments to explore the laws of motion. It does not displace the need for actual laboratory work, but adds a fascination, and makes for a pleasant classroom environment in which students help each other. Because software can solve algebraic functions fast and accurately, students said they were freer to focus on understanding of concepts rather than on repetitive calculations. Pictorial presentations make such functions more easily grasped. Mathematical modelling can be used in biology to show how populations change over time according to different starting parameters, while simulations and videos can show how the human body works, how a cell functions, and how oxygen is transported.

The use of CD-ROMs can lead to exemplary learning sequences, but this is by no means necessarily the case. In a reported biology class, the available CD-ROM was found to be difficult to use and unclear in its presentation. The teacher struggled with it, but eventually the class went back to more traditional methods. Students sometimes found inadequate guidance as to which disc to choose from those on offer, many being inappropriate. In one school, of the 50 titles notionally available, only 8 could be accessed. There were problems, too, over inadequate numbers of computers, making it difficult to book one in the time available to a student or a class.

Software is seen to be powerful, but not invariably user-friendly. Students can be left to their own devices, with inadequate preparation, and so take an inordinate amount of time to learn to use it. An example given was the learning sequences within software designed to improve typing skills, at times too easy but becoming too demanding. Because teacher intervention was required to guide through the sequences, little time was left to help those in specific need, and the motivation of many in the class was lost. In another reported case, problems arose in relation to programmable calculators: those with previous experience finished their tasks in a short time, but the teacher had no time to instruct others in the basic concepts without which they were unable to proceed.

The use of ICT in education can encompass a range of approaches effectively. At a relatively straightforward level, when a CD-ROM provides an alternative to conventional encyclopaedias, the gain is in convenience, effectiveness and

attractiveness rather than any radical change in learning methodology, as illustrated by the following student quotation:

> In school we frequently used interactive encyclopaedias (...) [that] thanks to an index allowed rapid access to the desired information. They were mostly very comprehensive, and provided another perspective on the classroom treatment. The links between articles helped us to pursue the subject in greater depth. Furthermore, the multimedia support (animations, images, etc.) made learning more enjoyable. The possibility of printing individual articles made it far easier to carry than having to take with you a heavy traditional encyclopaedia.
>
> Participant in OECD International Student Network

More radical would be an integrated learning system designed to replace the teacher – at least in part – for the development of a course unit. In mathematics, for instance, this could be mastery of the techniques of long division, where the approach might offer a more effective alternative to traditional written exercises. As students work through problems, benefit arises from the instant feedback, intended to prevent errors or misconceptions being reinforced. Even further from traditional approaches would be a student holding a videoconference with a fellow student in a foreign country to discuss global warming, through which they each develop their language skills and mutual understanding. This goes well beyond the traditional boundaries in promoting autonomous learning. These varied approaches serve quite different purposes, involve different methodologies, and are likely to suit different curricula.

- *ICT-based learning materials vary considerably in subject coverage, suitability of learning sequences and user-friendliness, but at their best are well-liked and valued by students.*
- *When ICT simply offers an alternative delivery medium (such as putting an encyclopaedia on CD-ROM), the gain to the learner is in convenience, speed, capacity, motivation and attractiveness.*
- *ICT can serve quite different educational purposes and methodologies, some of which extend well beyond the traditional curriculum. Used wisely it enhances knowledge, language and communication skills, collaborative learning, understanding and respect for others.*

STUDENT-CENTRED LEARNING

There is wide acceptance among many educators that individual learners construct their own understanding, by building on previous experience. According to this approach (sometimes described as "constructivism"), understanding arises as learners through prolonged engagement relate new ideas and explanations to their own prior beliefs. It implies that working with concrete problems develops the capacity for deciding how and when to use existing skills. Personal knowledge building in this way forms a useful model across the curriculum, implying that an appropriate learning programme is likely to include projects, group work, problem solving, reflective writing and other tasks that stimulate meaningful thinking (adapted from Ravitz *et al.*, 2000).

This learning model is highly relevant in an ICT-rich environment, in relation both to increasing understanding, and supporting the development of thinking skills. The particular facility of some forms of ICT is to provide a more open environment that promotes autonomous learning; it affords an opportunity to be grasped, with teacher guidance and support. Teachers will work collaboratively with their colleagues to share expertise, focussing on the activities and needs of individual students and small groups. Much classroom work has been developed using content-free software, such as word-processors, spreadsheets, Web-authoring tools and presentation packages, which form the basis for creative cross-curricular activity. Student engagement is enhanced where the computer is integrated in this way, and where teachers are willing to break down disciplinary and unit boundaries (Sandholtz *et al.*, 1997).

The Mönsterås High School development is an example of an innovative school in Sweden using a high level of ICT to support problem-based learning within the national curriculum (Dennersten, 1999*a*). The teacher no longer teaches the students directly, but creates an environment for successful learning, and acts as a source of inspiration and support. Key elements in the method include defining a problem, searching for information and evaluating it, reporting the results and drawing conclusions. Students choose their projects and engage in their own research, which extends to independent work outside school. All teachers and students at Mönsterås High School have been given their own portable Macintosh computer, equipped with *Claris Works*, e-mail and a Web browser. The school has a local network, an Internet server and a mail server, to which all classrooms, group-rooms, the teachers' room and even certain activity rooms are connected. The project approach has encouraged cross-curricular work,

for example history and language teachers working together. Teachers and students are very positive about the scheme. Parental enthusiasm is so strong that private schools are beginning to adopt the same approach.

Another example is the Methodist Ladies College in Melbourne, Australia, which provided each Year 7 student with a personal computer (McFarlane, 1997, p. 174). The college wanted to adopt a different learning style that could be supported by ICT, in pursuit of which the formal structure of 40-minute lessons was abandoned. The students became more pro-active in their learning, without the loss in social and creative experience that some had supposed inevitable. The working tasks expanded beyond traditional subject boundaries, as when "some children began to use French in a mathematics context – the first time the French teacher had ever known children to use French voluntarily outside a French lesson". Teachers became *consultants* within the learning environment and were no longer *controllers* of it.

Schools engaged with ICT can experience more than one type of benefit for learners. In the SITES study (Pelgrum and Anderson, 1999, p. 223), schools using ICT reported gains in knowledge and skills, motivation, responsibility and independence. Such gains are well illustrated from a UK primary school:

> Year 6 students in a Lancashire primary school visited a residential centre in mid-Wales in the Autumn term. The main objective was to carry out a comparative study of the weathering of different types of rock, using the gravestones in the nearby cemetery and in the graveyard back home. They entered information about the types and age of the stones used, and graded each entry according to how weathered it looked. Subsequently this information was transferred to a spreadsheet and plotted as graphs and charts for comparison with local headstones. Whilst collecting data on the field trip some students noticed the predominance of certain family names on the headstones. This led to a discussion about how to organise databases in order to facilitate searching and sorting. This project went on to involve an exploration of the impact of industrial pollution (by communicating with students in other regions) and an analysis of the age at death, which led to an exploration of social history.
>
> From the NCET Portables Pilot, UK, adapted from Stradling *et al.* (1994)

ICT can sustain differentiated activities for different learners within one classroom. A teacher may use software to provide challenging activities for groups of learners, thereby freeing time to work on a more individual basis with other

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students. It brings media richness, both in learning materials and in the creative work produced by the students themselves. The value of this goes beyond multi-media learning, and may help to accommodate differences in learning styles. Closed applications, such as didactic software that rehearses basic skills, may have a certain usefulness for all learners on occasions. They have proved especially useful in engaging less-able learners, in part because the computer is seen as impartial and able to give feedback on errors without the negative associations of teacher criticism.

Significant benefits have been derived from the use of ICT by students with special needs. While this cannot be analysed in any depth here, it is important to note that in certain countries special schools were among the early adopters of the new technologies. ICT has allowed children with visual and muscular difficulties to read, write and express themselves. In some cases the technology has allowed children with special needs to attend ordinary schools. Canada has seen benefits for students with intellectual and learning disabilities, those with visual and hearing impairments, and those for whom English is a second language; gifted students also have benefited (Council of Ministers of Education, Canada, 1999).

- *The notion of constructivism – individuals developing understanding, through building on previous experience – is widely acknowledged. It favours the use of projects, group work, problem solving, reflective writing and other tasks that stimulate thinking, all of which can be sustained by ICT.*
- *Student engagement is often enhanced in an ICT-rich environment, with appropriate teacher guidance and support.*
- *In certain countries, special education was the lead educational sector in exploiting ICT, with major benefits for students with special needs. The ability of ICT to support autonomous learning is advantageous to all and provides an opportunity to be grasped.*

STUDENT ASSESSMENT

The changes which ICT can bring to education are profound, but what are the implications for the assessment of student performance and certification? Voogt and Odenthal (1999) have proposed a series of *emergent practices* associated with the integration of ICT in education, which imply and invite radical change. They see an emphasis on skill development and on cross-disciplinary activity more in keeping with real life, developed and accredited through formative and

summative student assessment by a variety of means, including portfolios. Students will themselves accept more responsibility for their own learning and its assessment, developing expertise in the process.

As learning objectives and procedures relating to the use of ICT become an increasingly important part of the curriculum, this should be reflected in the assessment procedures. Testing of basic ICT capability – such as the ability to use spread sheets in simple ways – may be demonstrated by a variety of means across the curriculum, or by practical exercises designed for the purpose. It may, however, be difficult to assess the more sophisticated levels of ICT skills and processes, except through realistic activities in which they can be displayed. Further research into appropriate techniques is needed here, but there is a principle to be followed. In so far as ICT is seen as or becomes a pervasive influence and working *medium* throughout the curriculum, its presence must be reflected in the assessment procedures to the same extent.

To illustrate, where word processors are used in schools under existing curricula and examination systems, they are rarely used in an iterative way. Beyond the correction of spelling and grammar, the text created usually remains undeveloped. The work created digitally is usually left at what in other walks of life would be described as a "first draft stage", and it is this – and no more – that is used to assess the student's understanding and knowledge (McFarlane, 1997). Opportunities for formative assessment through the process of drafting, editing and re-drafting are lost, and the higher-order objectives made possible by word-processing and multimedia are left unattended, as though unimportant (McFarlane *et al.*, 2000). The need for coherence between curricular objectives and assessment procedures is illustrated from New Zealand:

> Despite this broad agreement, some of the official curriculum documents present a confused message. The New Zealand curriculum statements for mathematics and science contain teaching ideas that suggest a constructivist approach. Yet the framework of the documents, with eight hierarchical levels of achievement objectives closely related to assessment, suggests a reductionist, behaviourist view of learning. The two very different and competing views on learning are mixed within the documents, and there is no clear indication of how the inconsistency should be resolved.
>
> New Zealand (2000)

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Unless assessment procedures faithfully reflect the levels to which ICT influences curriculum delivery and associated learning outcomes, they will lack validity. In consequence, the benign influence of ICT across the curriculum will be severely constrained. US examination candidates who are active computer users appear consistently to under-perform in paper-based tests (Russell and Haney, 2000). Teachers preparing their students for conventional examinations will feel obliged to avoid such risks, and modify their programmes accordingly. The nature of any assessment system has an influence on the curriculum, and has a powerful role in defining the *real* – as distinct from the *intended* – curriculum.

Secondary schools in Ireland – and no doubt in other countries – have a major emphasis on formalised assessment that leads to "a tendency to narrow the curriculum and force teachers and students to focus on examination results" (Morrissey, 1999). Nevertheless, a pilot project allows students of the Leaving Certificate Vocational Programme to submit a multimedia product generated in *Hyperstudio* as part of a portfolio for assessment, an option that appears to be attractive to many students (NCTE, 1999). Similarly, in Sweden, a very flexible approach allows schools much freedom to establish their own assessment procedures (Dennersten, 1999*b*).

Several countries are experimenting with the expanded use of ICT-based examining. An area of interest is the use of ICT-based project work as a significant component of formative and terminal assessment, including individual students building their own electronic portfolios throughout each phase of education. This is one means for at least an element of the assessment to be compatible with an open and exploratory curriculum. In some Canadian jurisdictions, students may now take their grade 12 examinations using computers and graphing calculators, and on-line testing is under scrutiny. In France the new concept of *travaux personnel encadrés* (a teacher-managed record of personal achievement) will offer frequent opportunities for ICT usage.

Assessment of digital content does present challenges, which has made some resistant to change. The ease with which digital material can be copied and modified raises the issue of widespread plagiarism, although anti-plagiarism software is emerging.[2] There is the risk that an assignment might be judged more for its technical competence than its content, as when a student's ability to create a page with sound might lead the teacher to overlook the trivial or irrelevant sound chosen (McFarlane and de Rijcke, 1999). If several students have

2. See, for instance, *http://www.turnitin.com/new.html.*

collaborated on a project – as is often desirable – it may be difficult to discriminate between individual contributions. Such issues notwithstanding, "the assessment frameworks must change to recognise skill-related attainment more highly", in order to promote the curriculum reform needed for ICT to be fully integrated (McFarlane, 2001).

The pervasive adoption of ICT in education both *requires* different assessment procedures and *provides* a variety of means. Within the learning process, ICT testing techniques can offer rapid formative assessment and feedback, to encourage motivation and stimulate self-directed learning. For certain purposes objective testing will be useful, especially if followed up by on-screen discussion of the options offered, with ultimate recourse to the teacher when necessary. Although the value of formative assessment has long been acknowledged, it has not commonly been undertaken on a useful scale, being very demanding of teacher time. ICT brings new possibilities for this deficiency to be remedied.

> Teachers recognise that one of the great advantages of this technology is that it gives students immediate feedback on their progress. It allows students to test themselves, checking to see if they have mastered a new skill, or have the knowledge required to move on to other work. Such techniques teach students that they have the capacity to improve. Immediate feedback can motivate students who might otherwise have very little interest in school. Students who get into the habit of checking their own learning are self-assessing, an important skill at a time when more and more people are required to consider how well prepared they are for jobs. As students take greater responsibility for assessing themselves, the pace of learning changes and becomes more individualised. All of this is altering the way schools and learning are organised.
>
> Canada (country note)

- *What is assessed in schools and how the assessment is performed exercises a very powerful influence on the curriculum. The potential of ICT will not be realised as long as assessment is primarily in terms of student achievement in single subjects, by means of conventional written tests.*
- *Progress in this direction has been disappointing, acting as a brake on the imaginative use of ICT. The promotion of advanced skills and competencies will fall short in assessment regimes that are overwhelmingly knowledge-based.*

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- *The pervasive adoption of ICT not only requires different assessment procedures but provides a variety of means to meet this need. Several countries are experimenting with ICT-based examining, including electronic portfolios.*
- *The value of formative assessment – regular informal updating of student progress and difficulties – is often acknowledged but little practised. ICT offers promising avenues for rapid formative assessments and feedback, to refine learning and teaching strategies.*

ICT DRIVING AND FACILITATING CHANGE

Curricula can be characterised as a spectrum ranging from open to closed. The closed (traditional) model presents a closely-defined set of content and rules which students are required to learn and reproduce. For this model, courseware and information sources are seen as most relevant when they follow the prescribed curriculum. Curricula may have been modified to incorporate ICT, but where this is limited to basic operational skills little additional intellectual challenge is involved. Not all applications of ICT serve to promote higher-order thinking, and those which encourage rote learning – useful on occasions for revision or consolidation – will not expand the scope for independent thought. We have seen compelling examples of the radical transformations brought about by ICT, but simply to say that computers are being used in school does not, in itself, necessarily imply any particular change in teaching style.

> Schools seemingly find it extremely difficult to actually integrate ICT into the teaching process (...). Some 90% of primary school teachers do use the computer during lessons, but what that actually means is individual use by pupils, for example those who are lagging behind, or pupils who quickly finish other assignments. At secondary schools, a third of teachers use computers during their lessons, in particular for such subjects as information science, vocationally-oriented subjects and mathematics (...). It is still proving difficult to integrate ICT into school activities and to make innovative use of it.
>
> Netherlands (2001*a*)

Why should it be proving difficult to integrate ICT? The closed curriculum cannot easily embrace the radical change that ICT invites, indeed requires. With a more open curriculum model, where the content is less prescribed, it is possible

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to focus on the skills needed to build and communicate knowledge. Here communication applications, creative frameworks and information sources all have a potential role. In Sweden, where ICT is integrated across the curriculum, and teaching has become more individualised, the curriculum has moved in this direction:

> The former Swedish system was characterised by very detailed curricula and syllabuses. Each subject was divided into modules with instructions from a national authority on what should be taught in each module, how long it should take, and sometimes also the teaching methods to be used. It was also stated when during the term each module should be finished (...). The present Swedish system represents the opposite approach. We now have goal-oriented curricula and syllabuses. Now the syllabuses specify the targets that teaching in different subjects should aim at, and the targets students should have achieved after the fifth and ninth year in school.
>
> Hylén (1999)

The more open range of activities afforded by ICT is well exemplified by its potential to develop *writing skills*. Even at its most basic, writing with a word processor rather than on paper is better motivating to some. Motivation may also come from the potential to create "professional-looking" documents, where the final product is of high quality even for learners with poor handwriting. Further gains can be achieved through the use of on-line technology to facilitate more authentic and engaging tasks, such as writing to learners in another school or country, or working collaboratively on substantial projects. On-line activities such as this gain in credibility and authenticity, since their purpose and outcomes extend well beyond the actual writing of text.

But there is more. The word processor offers the ability to easily modify, correct and re-structure documents. Text becomes a mutable entity, to be revisited, extended and revised so that it reflects a growing understanding, a growing personal knowledge. In addition, there is increasing use of non-linear forms of writing using hypertext systems, and of multimedia, as pictures, sound and video are integrated into texts. Such freedom to decide how topics or ideas should be presented, according to perceived relationships, is likely to make the processes of categorical thinking and analysis more explicit to students (McFarlane *et al.*, 2000).

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As many students are at a stage of their cognitive development when their written expression is not sufficiently sophisticated to describe complex networks of associated ideas, multimedia authoring may encourage self-directed learning and genuine self-expression (Bonnett *et al.*, 1999). It offers the possibility of *realising* structure in a manner that reflects the thinking process itself and the organisation of human memory. The very processes of producing multimedia "texts" are likely to assist the accomplishment of conceptual and procedural activities, such as the definition of relationships, consideration of the appropriateness of information for different readers, and the use of argument to establish or review different positions.

The writing skills example illustrates the enormous potential of ICT to expand the learning experience, a potential largely untapped when ICT is merely used to do traditional things in a different way. There is, however, considerable *tension* between traditional curricula and a more open, skills-based approach. Even where new skills are incorporated in a curriculum, there will not be the time to develop them effectively unless there is a corresponding reduction in the amount of factual detail prescribed. The tension will be especially evident where conventional assessment and certification procedures, or back-to-basics emphases, are sustaining traditional aspirations. This very tension can be turned to advantage, however, as ICT becomes both the *driver* and the *facilitator* of radical change across the curriculum. Canada provides an example:

> Many educators see the new information technology as a catalyst for a revolution in the classroom, since it requires new approaches to learning and teaching if its full potential as a learning resource is to be realised. Further, information technology promotes a restructuring of the curriculum for elementary and secondary schools, with a renewed focus on the skills of accessing, managing, and processing information, collaborative working skills, problem-solving, and learning to learn.
>
> Canada (country note)

➥ *The closed, traditional curriculum, based on well-defined content and rules which students must learn and reproduce, stands in the way of ICT integration. Powerful tensions exist between traditional curricula and the more open, skills-based approaches supported by ICT.*

- *In more open curricula with less prescription, there is greater room to focus on the skills needed to build and communicate knowledge. As ICT gains acceptance in schools, it may become both the driver and the facilitator of such radical change.*
- *Greater use of ICT and the development of students' writing may powerfully reinforce each other rather than be in conflict. The technical scope of word processing can facilitate more engaging tasks and be highly motivating.*

DIGITAL LITERACY – AN EDUCATIONAL POLICY IMPERATIVE

A parallel has emerged between the concept of literacy and the sophisticated processes and activities that ICT has made possible across the knowledge domain, encapsulated in the notion of *digital literacy*.

> Societies consider high levels of literacy to be desirable for all of their members to sustain widespread participation in economic, social, cultural and political life. Literacy is important for communication and making informed decisions. It is a necessary ingredient for citizenship, community participation and a sense of belonging. Literacy is also a tool for efficient learning, particularly self-directed learning of the sort that is enabled by information and communication technologies.
>
> OECD (2000*a*), p. 83

Just as "conventional" literacy is more than basic ability to read a sequence of words, digital literacy is more than ability to use a computer in simple ways. Acquisition of basic ICT skills is important, but no more than an initial element, since change is rapid, and simply learning to operate existing technology will be of limited usefulness. The need is to understand the potential of the technology, and to acquire confidence and skill in adopting it for appropriate applications. This means being a critical and discriminating, as well as confident, ICT user. At the OECD roundtable that concluded the work of the International Student Network,[3] the analogy was drawn with driving a car. It is one thing to know the rudiments of gear-changing and so forth, but quite another to navigate purposefully, to have a sense of direction and strategy. Digital literacy embraces

3. See "School Technology through the Eyes of its Users", Report on the Aix-en-Provence Roundtable, *http://bert.eds.udel.edu/oecd/roundtables/roundtablesframe.html.*

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a sophisticated skill set that has revolutionised the workplace and community life, and is increasingly required for full engagement in society.

Some earmarked time and courses might need to be devoted to digital literacy within the school programme. Individual subjects might not easily find the time, for instance, to go into the protocols of Web page production, advanced Internet search, or working with multimedia. Each subject would benefit, however, from the availability of such expertise, to be integrated within the learning activities they offer. The richness of the learning environment would thereby be enhanced and further support given to the foundations for lifelong learning.

ICT use enriches the school curriculum in at least two fundamental ways. The first is as an enhancement across almost every subject and activity, through resource banks, simulations, learning sequences, collaborative activity and so forth. This in itself has the potential to transform the learning environment more than any innovation hitherto. The second, and yet more radical, is the pursuit of digital literacy in its own right, whereby the individual becomes empowered as a discriminating and autonomous learner.

- *ICT integrated across school subjects and activities has the potential to transform and enrich the learning environment more than any innovation hitherto.*
- *Digital literacy refers to a sophisticated set of competencies pervading workplace, community and social life. Individuals need to understand the potential of the technology, and to become confident and competent, critical and discriminating in using it.*
- *There may well be advantage in devoting occasional supplementary school programmes to digital literacy, in addition to the cross-curricular use of ICT, to enhance skills and strengthen the foundations for lifelong learning.*

CHAPTER 3

EDUCATIONAL SOFTWARE AND DIGITAL CONTENT

The importance of educational software (tools and applications) and digital content (learning materials) needs to be recognised if the huge educational investments in hardware and infrastructure are to realise the expected improvements in learning and schooling. In a recent OECD publication (OECD, 1999), an annual and growing ICT expenditure of US$ 16 billion was estimated across Member countries for primary, secondary and tertiary education. Mostly, however, the expenditure was on hardware and networking, with little on software and content. Whilst this low expenditure may be expected to increase, a frequent criticism by teachers is of a lack of relevant materials.

The adoption of ICT in education has followed the development of a more general world market trend, in which hardware advances have been closely followed by the emergence of commercial software to exploit the new opportunities. This sequence depends on the prospect of sufficient sales and continued expansion to sustain the investment, but for the most part the broader ICT market has not regarded education as its central concern. In consequence, the software and digital content offered to education have not necessarily matched well with curriculum objectives and pedagogy. The educational market, while potentially huge, has developed only slowly.

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The range and context of educational applications must be considered in more detail, in order to address these concerns about the scale and quality of software available for use in education, and to clarify what action might be needed.

> The term educational software is widely used and rarely defined or even explained. If we take it to mean software used in an educational context, it is a term which embraces a wide and eclectic range of tools and resources. Indeed the term encompasses a collection of entities so variable that the dependence on a computer-based environment gives an appearance of homogeneity that does not bear close scrutiny.
>
> McFarlane and de Rijcke (1999)

VARIETY OF SOFTWARE AND EDUCATIONAL USAGE

The ICT applications used in education differ greatly in their impact on teaching and learning, and can support widely varying educational objectives. Some of them, such as computer-projector systems, involve additional hardware. The following classification is adapted from McFarlane and de Rijcke (1999):

Type of application	Examples	Educational use
General tools	Word processing, presentation, spreadsheet, multimedia authoring, including Web publishing.	Becoming more-and-more important; require innovative and creative thinking from the teacher; quality is in the application, not the tool itself, since such tools are not dependent on particular content.
Teacher tools	On-line lesson outlines; computer-projector systems; whiteboards.	Lesson preparation; whole class teaching with shared view of screen; interaction managed by teacher.
Communications	E-mail, e-learning; video conferencing, Internet browsers.	Require a view of education as reaching beyond school, for which they offer huge potential; familiar in the out-of-school context.
Resources	Especially Web-based, whether general or specifically educational.	Used according to availability, in whatever way wished; for resource-based, skills-oriented learning.

Type of application	Examples	Educational use
Computer-assisted instruction (CAI)	Drill-and-practice, related to a certain kind of content and relatively unsophisticated.	Offers individual learning opportunities without expensive development; appears to fit well with transmission models of teaching and learning.
Integrated learning systems (ILS)	Individualised task assignment, assessment and progression, including CAI, with recording and reporting of achievement.	These appear to sit outside teacher-led instruction and learning, but are only truly effective as an integrated part of the learning process, which may have to be re-thought.
Computer-based assessment tools	Examination boards are developing computer-based examinations, which attempt to mimic paper-based tests.	Components give advantage to the computer literate; teachers will need to incorporate some elements of similar tasks in their teaching, in order to prepare students adequately.
Management tools*	Classroom procedures	Students' progress, deficiency analysis, etc.
	School administration	Financial, personnel and educational resources.
	Publication of results	Parents, governors, inspectorate, general public.
	Communication	*e.g.* school to home and vice versa.

* Little is known about the effects of these four kinds of management tools on the quality of teaching and learning.

Several of these applications – notably in the first four categories – are not specific to education. They are, however, highly desirable within schools, since familiarity with them is increasingly essential in contemporary society and they can serve certain educational purposes well. The general tools and communication techniques can be very effective in fostering a participatory, student-centred learning model, while the teacher tools can stimulate the interactive dynamics when whole-class teaching is appropriate. The resources and techniques available for the management of the learning environment enable it to function more efficiently, better able to serve the needs of the individual learner.

Software used in schools varies widely, so that notions of quality and its assurance cannot be based on reductionist principles that assume a non-existent homogeneity.

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For any of these applications, whether education-specific or not, the pursuit of quality calls for attention to a range of considerations, as presented in the next section. These dimensions of quality are partly intrinsic to the materials themselves, partly dependent on the use to which they are put. The overall evaluation of the quality of the software and digital content use in the learning situation will depend on the positive resolution of several or all of these dimensions simultaneously.

- *There is a wide range of software and digital content used in education, much of which was not specifically developed for educational environments. The range covers general tools, teacher tools, communications, resources, computer-assisted instruction, integrated learning systems, computer-based assessment tools, and management tools.*
- *The complexity and diversity of ICT use must be fully reflected in concepts and strategies relating to judgements of quality, which will depend on the use to which the materials are put as well as the properties intrinsic to the materials themselves.*

DIMENSIONS OF QUALITY

Educational purpose

The desired educational outcomes are the starting point for the evaluation process, since quality has meaning in relation to how well those outcomes are served. It is often the case that the software available to schools was designed primarily for other purposes in industry and commerce. How well, therefore, can it meet educational needs?

> All the main word-processing applications – still the commonest use of computers in schools – were designed for business. The same is true of spreadsheets, databases, e-mail software, Internet browsers, video conferencing applications, etc. Consider, for example, how a word processor designed for education might track the original text a child produced rather than the grammar- and spell-checked version. A teacher could then judge the degree to which a child could operate independently of the technology in those areas. Also consider how long it took for spreadsheets to offer easily accessible x/y plots, probably the commonest plot in secondary mathematics and science, and still not supported by some commercial spreadsheets.
>
> McFarlane and de Rijcke (1999)

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To an extent, we have to judge the software for what it can do rather than what it cannot, and even then may only be interested in a part of what it offers. There does not have to be a perfect match between the software in its entirety and the needs of the educational user, only that it supports a sufficient combination of desirable outcomes. Digital content, for instance, might cover a subject over a range of levels of sophistication. So long as one of these levels is well matched to a particular learning situation, it can be deemed *for that purpose* to be conducive of high quality.

Mode of use

Some of the first enthusiasts for ICT in education argued that it could be designed for use regardless of teachers, allowing students to progress independently and to monitor their own progress. It was supposed, for instance, that high quality and exemplary classroom practice could be recorded for subsequent use elsewhere, with little need for teacher mediation. These simplistic models saw teachers as no more than gatekeepers, whose decisions were merely about where, when and for how long students should use the ICT-based learning materials. Learners were assumed to be self-motivating, regardless of their age, educational attainment and individual needs, and able to grasp unaided how to relate the learning they acquired to novel contexts. Experience has shown these assumptions to be ill-founded.

Some integrated learning systems are almost wholly *closed*, in the sense of requiring no teacher input, and have sometimes even been promoted as *teacher-proof*. They attempt to gauge the level of difficulty at which students should commence and the rate at which they should advance, with automatic feedback on progress made. The designers have made decisions over the selection, presentation and progression of content, task design and assessment, as well as the nature and timing of feedback to the learner, which together create an implicit pedagogy. That the system operates with such built-in assumptions may go unrecognised, but lead unwittingly to conflicts of cultural or educational practice:

> (...) if learners are to make connections between their own intuitive knowledge and the method or methods for solving problems programmed into an ILS, then either they must forge the connections for themselves (which may be too hard for many) or someone else needs to be on hand to help them towards an appreciation that there is typically more than one way of representing a situation, thinking about it and solving the problems it presents.
>
> Wood *et al.* (1999)

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Available educational ICT materials now range widely in the intended extent of teacher involvement and mediation. It is therefore important for teachers to have in advance adequate information on their content and methodology. As teachers gain confidence and experience with ICT, they will incorporate it imaginatively into their classroom practice, drawing especially on the more open materials that offer scope for adaptation to perceived student needs. Commonly, and contrary to early expectations, ICT-based learning materials will usually be adopted for part of each course and of each school day – albeit a significant part – but not be the whole.

Where ICT is adopted in education, whether general tools such as spreadsheets and databases or digital content, the role of the teacher is crucial in selecting and building materials, and in alternately *leading* and *supporting* ICT-based learning. What suits one set of classroom circumstances will not necessarily work elsewhere. The expertise of the teacher must embrace a range of teaching styles, including knowing when and how to use ICT, which identifies priorities for in-service and continuing professional development. Beyond the characteristics of the ICT materials themselves, it is the teacher who is the main determinant of the quality of the learning environment.

Needs of individual learners

Suppliers who are well informed about education (often from collaboration with practising teachers) will recognise the importance of matching their products to the needs and characteristics of the target learners. It is essential that the language used should be at the right level of complexity for the age range in question. Where digital content relates to learning a foreign language, for instance, realistic account must be taken of likely vocabulary capability. To the extent possible, there should be options built in for different student-ability levels. Whilst this should be a functional advantage of digital tools and content, it is rarely exploited in the materials so far developed.

In most countries, commercial suppliers provide the bulk of available education materials. They will naturally seek to maximise their sales, which leads some to pitch at the school *and* the home market simultaneously, with sometimes questionable results:

> Sweden is a very small market for educational CD-ROM products, the school market in particular not being big enough. Producers have to sell their products also to parents, especially before Christmas, in competition with all kinds of games. The result of this has been a compromise, unfortunately not a successful one.
>
> Dennersten (1999*b*)

The resulting compromise is an example of what has been dubbed "edutainment". While marketed as of general educational value, it is unlikely to have the specificity to match particular learning objectives. Meaningful dialogue between the producers and the users is needed to address the problems.

Robustness and user friendliness

As many teachers can attest, products that on first impressions seem to be of value may prove disappointing in classroom use. Programmes may contain an unacceptable level of "bugs" or lack user-friendly navigation systems, and content may prove trivial or error-prone. While problems may sometimes lie with the hardware rather that the software, preparing products for classroom use may prove intricate and time consuming. Video-conferencing, of such obvious educational potential, is as yet too often unreliable. As schools become networked, especially on a local area basis, software delivered by the server must perform as well as it does with stand-alone machines. In the pursuit of quality, teachers and learners must be able to have confidence in the reliability and effectiveness of the products and procedures.

Added value

Some digital content has done no more than replicate existing learning methods in technological form, for instance putting on screen what can be found on the page of a book. Little is thereby added, except the ability to manipulate or download the material digitally, while the digital versions may lack the editorial quality of the printed page. Improvements in the speed and memory of computers, however, have opened up a wide range of options, including rich databases of factual and visual material and inter-activity between learner and programme. With continuing technological development, the range and extent of inter-activity will further increase, enabling more sophisticated exchanges and programme interrogation. Simulations can present real-life contexts in hitherto unimagined ways. There is now scope for students to assemble and create their own products, combining differing media and state-of-the-art content. This points to the "value-added" dimension of quality in ICT materials and use – the extent to which they provide desirable educational resources and tasks that would not otherwise be possible.

Cultural relevance

Software and digital content developed specifically for use in education should be sensitive to national, regional, or local expectations. Countries will

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have specific national or minority language requirements and want to promote their own identity. The high costs of software production and distribution demand a large volume of sales, so commercial pressures may often lead towards convergence on a single linguistic and cultural model. Widely-marketed products from the United States provide the most obvious example of this. Tools and digital content in such languages as Norwegian, Danish, and Dutch offer few markets outside the individual countries, and – with small populations – limited commercial prospects internally.

As an alternative, the "versioning" of digital content to meet national needs is becoming more frequent. Besides translating the language of the software, changes may well be needed to illustrations – mathematics materials might use an unfamiliar national currency, and geography inappropriate exemplification of climate or world region. More profound "versioning" issues arise in relation to cultural attitudes and perceptions. In history or literature, for instance, national perceptions of events or reputations may vary widely. Sensitivity to these factors is required, against a background of classroom experience, in making such adaptations. The relatively low cost and ease of Web-content generation – as opposed to the large-scale programming costs of early CD-ROMs – is an important development. It will help to promote the democratisation of digital content, and the interests and concerns of any individual, group, community or nation.

Avoidance of stereotypes

The new media, within and outside education, have a powerful effect on attitudes among young people. It is important in creating digital content for education to avoid the promotion of outdated or undesirable imagery, especially in the depiction of people and attitudes. Much concern has been expressed, for instance, over the amount of gratuitous violence in the computer games market, and its orientation towards boys. Positive or negative messages can be carried unwittingly by the selection of examples, the use of animated "guides", and the way men and women are depicted. Regional and local characteristics, for example dress and speaking voice, can influence attitudes in sometimes undesirable ways. Sensitivities may be raised by the religious, moral or ethical overtones of curriculum material. Obviously, no absolute rules apply in situations of this nature, and some subjectivity in making judgements is inevitable. Part of the solution to such uncertainties lies in students themselves becoming informed and critical users of digital texts, able to challenge and critique the information they find on the Web.

Affordability and mode of delivery

Although a less-obvious criterion of quality, the costs associated with a particular product will in part determine its educational value. For instance, sharing CD-ROM resources over a network is not just a matter of making the connection, but requires the availability of some technical expertise; purchase of a CD-ROM often implies merely a single-user licence, and additional costs arise for multiple-outlet use and updates. Should site licences be disproportionately expensive or restrictive, the educational return on the investment might turn out to be less than could have been achieved in other ways.

Once a school is networked, the Internet model of digital content delivery has attractions (see Chapter 4). Materials are often free (though this will not necessarily remain so), and are readily available apart from any problems over downloading. Even when they are not free, a school may be able to preview a product before purchase – thus overcoming a long-standing difficulty with digital content selection – and in some cases obtain updated versions subsequently at no extra cost. The Web sites can be accessed from every machine, and the sites cannot be damaged or lost through user action.

Different user-interface designs – a variety of buttons and symbols in different places on screen – has often required undue time for familiarisation before use, but increasingly designers are making their products similar to the Web interface. The short-term benefit is that educational materials become easier to use and learning is faster. Over the longer term, it contributes to the growth of universal user-interface standards. For commercial suppliers of digital content, Internet growth has led to an alternative low-cost distribution system, making small-volume production more viable, and allowing the development of Web resources to serve very small niche areas.

- *The quality of software and digital content is best addressed by application of open and flexible guidelines rather than a fixed set of criteria.*
- *Any evaluation of the quality of software and digital content will relate to:*
  - *matching the educational purpose and mode of use anticipated by teachers and learners;*
  - *matching the differentiated characteristics/needs of individual learners;*
  - *product robustness and user friendliness in the classroom and elsewhere;*
  - *value-added compared with alternative approaches;*
  - *harmony with cultural perceptions, with avoidance of stereotypes;*
  - *affordability and ease of access.*

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SOFTWARE AND DIGITAL CONTENT GETTING INTO SCHOOLS

Many education systems are still at an early stage in recognising the role of ICT and incorporating it in schools. Faced with many other priorities competing for available resources, they have made no more than a modest commitment to adopting digital learning materials and techniques. Only now is progress being made towards organising the development of professional ICT competence for teachers. A consequence of the slow adoption of ICT in education is that commercial understanding of specific curriculum needs is frequently inadequate, and the market is under-developed. Large companies find the extensive and less-demanding home market easier to target, while smaller, educationally-expert companies may lack the financial resources to develop specialised products on a speculative basis. There is no clearly-defined target for product design within fast-changing delivery systems, and pedagogic research and practical experience are only beginning to yield lessons on how best to proceed.

Government initiatives

Faced with this situation, some countries have based reform on small-scale initiative and experimentation. Others have commissioned products to meet particular needs or to stimulate the commercial market, though such approaches carry risks. The products so developed may not meet expectation, or may be overtaken by technological advance, rendering them of limited value. Governments must judge the risk that they are willing to bear, the extent to which public intervention is justified to "kick-start" an internal commercial industry, and whether it will be able thereafter to sustain itself without unacceptable levels of public support. A suitable balance needs to be found between commercial products and those expressly commissioned with the needs of teachers and the curriculum in mind.

A specific initiative to encourage digital content production of quality has been taken in Italy, where the Ministry of Education launched a competition to identify 100 schools able to lead in the development of multi-media educational materials. The Japanese Ministry commissioned business and educationalists – working in consortia – to develop items that would use the full potential of the technology to support specific educational activities, and encourage ICT usage generally. It is one thing, however, to promote the development of a small number of exemplary items by such means, but another to establish a sound and comprehensive corpus of effective learning materials available across schools to teachers, learners and parents.

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Authorising software purchase

Reflecting the variations in national education systems across OECD countries, there are wide differences in the level at which choice decisions are currently authorised and made. Practice ranges between allowing schools complete freedom to select materials within curriculum guidelines and authorising approved lists for purchasing at national, regional or school board level. In Canada, for instance, materials are generally approved at the provincial/territorial level. The usual practice is for purchasing policies and guidelines to be set which proprietary vendors must follow. School boards and teachers will generally use digital content that has received provincial authorisation, though individual schools and libraries may also choose other content or resource-based materials that match specific school learning needs.

In a number of countries, decisions on purchase are taken at the school level, with individual teachers or curriculum departments playing the crucial – and professional – role. Thus all such decisions in France rest with the educational institutions themselves, which have earmarked funds available. The Belgians (Flemish Community) make specific funds available to schools for free choice and purchase of hardware and materials. In Ireland, responsibility rests with individual schools, costs being met by capitation grants from the government. UK schools have dedicated funds for purchase of software and digital content, within the ICT grants offered to them under the National Grid for Learning programme. Selection and purchase are matters for the individual schools, and licences may be negotiated at local education authority level to enable wider use of particular products.

Procedures may vary between educational phases. In Luxembourg, selection and purchase decisions are taken by the local authorities for pre-school and primary schools, while at secondary the choice lies with the schools themselves, purchases being financed from their regular budgets. Purchasing responsibility in Norway lies mainly with the school authorities – community, county or private foundation. In Greece, it is the Ministry, through the Pedagogical Institute, that plays a major part in both the selection and management of commercial supply contracts for multimedia materials. There is an obvious requirement on public authorities to seek due economy in purchasing, which is most likely to be achieved with some form of collective purchasing agreement. This may be advantageous from the commercial standpoint, since marketing to individual schools and teachers may raise additional problems of cost and logistics.

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- *Sustained dialogue is needed between ICT suppliers and the education service, to improve the range of software and digital content available to schools. Governments may need to promote such dialogue and share some of the risk of new development.*
- *There are wide differences between countries and levels of education in the ways choices are made in purchasing digital materials for schools. Some central purchasing of software and digital content may be needed for economies of scale, but much discretion will need to lie at the local level.*

SYSTEMS FOR QUALITY EVALUATION

Overall, it must be clear what any evaluation process is designed to achieve, perhaps a formal "approval rating" or "accreditation" of materials, perhaps an estimate of minimum adherence to declared criteria. The gradual early entry of ICT into education was often led by enthusiasts, who either produced their own digital content, or used their experience and contacts to select from the initially small pool of materials available. Quality assurance in those circumstances was largely a matter of subjective personal judgement. There were few systematic attempts to categorise products, and no established criteria for doing so.

In an early scheme, when the UK government funded the introduction of CD-ROM drives and discs to primary schools, available commercial products were evaluated for content and curriculum relevance. The results were promulgated to schools and posted on the Internet. Although these evaluations were rapidly undertaken (causing concern on that account to some commercial producers), they were conducted by experienced evaluators applying criteria consistently. The interest aroused nationally and internationally revealed the scale of demand for soundly-based and reliable product information, so that many education authorities have instituted their own procedures to meet this need (NCET, 1994).

The development of formal evaluation systems through a relatively short history shows attempts to reconcile a variety of interests and concerns. Evaluations must take account of the nature of the materials, since general tools and courseware, for instance, require different criteria. Some judgements in every case will be needed on technical standards. For digital content the process must consider the match with the local, regional or national curriculum requirements, and should lead to easily-accessed information for teachers on subject coverage,

intellectual level and ease of use. Commercial suppliers will benefit from objective evaluations that are expertly and rapidly undertaken, to reflect the fast-moving commercial world where product life may be short. Questions may arise about the extent to which a commercial producer may use an evaluation to advertise products.

The examples of evaluation schemes which follow are not intended to provide any form of comprehensive summary, but to illustrate the variety of approaches adopted and identify the concerns to be addressed.

US, California Instructional Technology Clearinghouse

Digital content proposed for use in Californian schools is considered against criteria that have been developed by the California Instructional Technology Clearinghouse since 1982[1] (Vaille, 1997). There are supplementary criteria for the different types of ICT application in educational use, such as tools and on-line resources. The clearing house, funded by various state and federal agencies, employs over 900 trained and experienced evaluators. It operates in 19 evaluation satellites spread throughout the State, each specialising in a particular subject area. For acceptance, a product must receive a favourable verdict from at least two evaluators, and only then is purchase authorised in the State schools. It is recognised that the evaluations are subjective, but the detailed criteria set the framework within which the evaluators marshal their evidence in the overall formulation of their views.

The digital content criteria are defined in five areas. *Curriculum Content* includes legal compliance (*e.g.* non-discriminatory) guidelines. *Instructional Design* looks for creative teaching and learning approaches, the promotion of critical thinking and media awareness, acceptance of cultural diversity, the extent to which non-native English speakers and those with special learning needs are supported. *Program Design* considers teaching and learning objectives, pedagogy, added value compared with traditional approaches, motivational features, interactive learning strategies and facility for customising the content and approaches. Additionally, it looks for evidence of the identification of supporting on-line links, and the scope for the development of skills beyond drill-and-practice. *Assessment* is concerned with diagnosis and feedback on performance, assessment strategies and ease of reporting to students and teachers. Finally,

1. See *http://clearinghouse.k12.ca.us/*.

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Instructional Support Materials relates to the availability and specification of relevant, well-organised, well-presented complementary materials and strategies in a variety of formats.

Sweden, Foundation for Knowledge and Competence Development

The Foundation for Knowledge and Competence Development, a public-private partnership in Sweden, launched a database for educational material – available both on-line and on CD-ROM – using publishers' promotional material and teachers' reviews[2] (Hylén, 1999). The publishers register their products, following which teachers give their opinions, based on actual classroom use. The database holds reviews of over 450 products from 86 different publishers and has 100 teachers registered as reviewers.

France

In 1998, the French Ministry of Education established a support structure for educational multimedia resources, that includes evaluation of commercial products. A group of specialists selects materials deemed suitable for the "stamp of approval" *Reconnu d'intérêt pédagogique* (recognised as of pedagogical interest). Of around 500 CD-ROMs evaluated in 1999, 240 qualified for approval. A list of approved materials (8 000 items by May 01) is circulated throughout the education system.[3]

Australian Science Teachers Association

In an approach for one curriculum subject (science), the Australian Science Teachers Association has been associated with a number of industry partnerships in the development of educational content and its subsequent quality evaluation (Althorp, 1999). Involving teachers in the development phase has resulted in *teacher-endorsed products* with the potential for ready adaptation in the subject area. The model has given a professional development component to the teachers involved, whilst at the same time using them to provide expertise to the industrial partners in the areas of subject content, pedagogy and classroom practice. Dialogue between the teachers and developers was conducted around a series of questions, relating to the ways in which the proposed materials and their activities

2. See *http://knut.kks.se/laromedel/.*

3. See *www.educasource.education.fr.*

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might link to teaching and learning. The questions form a useful checklist for content development:

- What are the potential curriculum outcomes?
- What conceptual understandings are involved?
- What process skills would students require or develop as a result of using the software?
- What background information do students require to effectively engage with the topic?
- Is there additional information on the subject that needs to be included on the software?
- Are there links to other curriculum areas?
- Are there recommended strategies to enable teachers to manage the resource within the timetable, within school structures, with a large number of students, with students from a range of backgrounds or cultures?

Althorp (1999)

Germany and Austria, Software Documentation and Information System, SODIS

In 1988, Germany began the development of SODIS, subsequently to be joined by Austria. The system is a database of materials judged capable of improving the quality of learning (Weber, 1999*a*). Mindful of the rate of development, evaluation criteria for the different types of applications were developed as questions, to be applied flexibly and subject to revision in the light of technological advances. Evaluation was led by a senior educator seconded for 2-3 years, assisted by subject specialists, released from their teaching for 6-12 hours per week.

The subject specialists judged whether to proceed with an item, from the 600-1 000 received annually. Each had a team of 5-10 teacher members, given training for three days a year. Team members, who undertook 2-10 evaluations per year, received for each a fee commensurate with the complexity of the task. The evaluators decided what weight to give the different criteria, and incorporated experience from actual classroom use in forming their judgement on a particular item. Often there were reports from different evaluators across the two countries. Once the evaluations had been posted on the SODIS site, views were welcomed from ordinary teacher users. Any conflict with the original evaluation was reconciled by the subject specialist. Of the 4 000 products registered in the

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database, evaluations are available for 2 200, of which no more than 120 had been deemed to be of exemplary quality.

Through this structure there were opportunities for professional development and the possibility of career progression. Over time, discriminating users of ICT became diffused through the education system, and some experienced evaluators became consultants to the industry. By 2000, however, the government of Northrhine-Westfalia – that had provided the bulk of the resources for SODIS – had identified other ICT priorities. It organises annual conferences at which teachers, publishers and multi-media developers review products, but SODIS is now managed by the other partners, perhaps to continue on a reduced scale.

UK, Teachers Evaluating Educational Multimedia, TEEM

In the UK the *TEEM* project was started in 1998, as a public-private partnership, with support from the government and elsewhere (McFarlane, 1999). Widespread consultation was undertaken with a range of professional bodies representing policy makers, publishers and educational practitioners. The primary purpose was to offer an information service *to* teachers, although it has in the process provided professional development *for* teachers. Evaluation criteria were developed for technical, curricular and pedagogic issues, in question form rather than as standards to be met, to give greater freedom and flexibility.

Teachers, who first undergo training, use the criteria to evaluate items, and give vignettes describing actual classroom use, for which they receive a modest payment. The emphasis throughout is on relating the criteria to a specific resource and context. A TEEM editor gives one-to-one support when evaluators prepare copy for the Web site,[4] which (May 01) carried nearly 200 such evaluations and was visited over 5 000 times a day, mainly by teachers. Feedback is invited from those who use the site, to enable constant review of the content, its presentation and the evaluation criteria.

The frameworks which guide the TEEM evaluators are also relevant to developers, since the questions to be asked of the product performance should be considered at the design stage. Moreover, the critiques often include comment on design features that can inform developers, for instance indicating particular features that make an item successful in the classroom. Maintaining the confidence of commercial producers is considered essential, since suppliers would bypass the TEEM system if it proved unduly prolonged, or produced poorly-

4. See *http://www.teem.org.uk/*.

argued results. The benefit of a favourable report will normally prove commercially valuable, so it is hoped that TEEM will become self-supporting through the fees charged for product evaluation, after a development phase with government support.

- *With the importance that ICT has acquired in schooling, soundly-based and reliable evaluations are needed on the digital materials available for schools. Teachers need easily-accessed information on subject coverage, intellectual level and ease of use. Such information is also of benefit to the suppliers of high quality products.*
- *There is a range of existing country experience in evaluating digital materials, including evaluation schemes that use detailed lists of criteria. In view of the growing number of materials and range of use, many schemes have moved from fixed standards to be met to criteria posed in question form.*
- *There is a critical role for teachers in the ICT evaluation process, which is most helpful when it incorporates judgements by teachers on actual classroom use. For the teacher, becoming skilful as an evaluator of digital content is an aspect of professional development.*

ICT AND TEACHER PROFESSIONALISM

The various systems for evaluation of software and digital content, notably SODIS and TEEM, have indicated that involvement of teachers is a key factor. This involvement has constituted a major element in teacher professional development. It has led to the establishment of a growing cadre of teachers who are better equipped to deploy ICT effectively in their own teaching, and to liaise meaningfully with developers. The notion of competence with ICT being an aspect of teacher professionalism is further pursued in Chapter 6.

Individual teachers will have an increasingly important role to play in the selection, creation and synthesis of materials, a responsibility that requires them to be digitally literate, and to have available systematic information on products, appropriately displayed. This implies a need for comprehensive, well-organised, and user-friendly procedures that give descriptions of available products and services, based on reliable evaluations that command the confidence of users. Experienced teachers empowered in this way will be able to reach their own decisions on products, their use and adaptation, to permit the best possible match to individual teaching and learning styles.

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The effective dissemination of information on materials and their quality has long been a difficulty for teachers and suppliers alike. Formal evaluations reach only a part of the potential audience, and direct promotion by suppliers to education authorities and schools has limited impact (as does any unsolicited advertising). Web-based information from specific sites and educational portals adds greatly to the comprehensiveness of the information available. Some teachers will pick up information at exhibitions, conferences and other professional development activities, or gain ideas from their colleagues. A UK study of purchasing advice in schools for software and digital content showed that ideas come mostly from informal recommendation (BESA, 2000, p. 100):

Information source	% of responding schools		
	little	some	high
Recommendation from colleague	4	41	55
Product review	12	64	24
Reviews & assessment Websites – NGfL/TEEM	21	59	20
Demonstration	14	54	32
Local Authority preferred list*	21	41	38

* Of particular importance to primary schools; all figures rounded.

The role of conferences, presentations and other opportunities for face-to-face contact will not disappear, although virtual Web-based meetings will add greatly to the possibilities for information exchange. There may, however, be changes in the way that these events are used, with contacts and initial "browsing" of products on-line before the actual meetings take place. This will permit a greater focus on discussion and consideration of specific products during the meeting, and opportunity for professional cross-fertilisation.

The evolution of digital materials to emulate the user interface of the Web, combined with the use of the Internet to give reviews and allow downloading, are resulting in a blurring of the boundaries between delivery via the Internet and by traditional means. Many products are hybrids, distributed partly on CD-ROM, partly on-line. There is a move to modularisation of content, in small topic areas, for selection and use as required. Teachers might take such modules, and join them together with others of their own, to achieve an ideal resource in a particular learning situation.

- *Teachers who become skilled ICT evaluators are thereby better equipped for their own teaching and to contribute to the development of software and digital content.*
- *Increasingly ICT-based materials used in teaching and learning will be partly commercially developed, partly produced by the teachers and learners themselves.*
- *Information about software and digital content is more-and-more being distributed on-line. To use it effectively and discerningly, teachers will need dialogue with colleagues, and sometimes the opportunity for face-to-face discussions with the suppliers.*

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CHAPTER 4

SCHOOLS AND THE INTERNET MEETING THE CHALLENGE

Internet use has expanded dramatically during the last decade, with parallel increases in the volume and range of on-line resources and services, making it a significant part of life for many people in developed countries. It is the channel that makes possible the transmission of one-to-one, or one-to-many communication, via e-mail, electronic conferencing and video conferencing, for exchanging messages at relatively low cost almost instantaneously anywhere in the world. It sustains the World Wide Web, that allows access to a vast array of published work. In both these ways, as *postal service* and as *library*, the Internet has revolutionised the means of communication across the world.

Some judge the major contributions of stand-alone computers to have already been made, seeing the future lying with communication between computer users. The Internet and World Wide Web have far-reaching implications for teaching and learning. They open up a remarkable range of learning resources and possibilities for interactive working. Ability to work comfortably with the Internet has become an important life skill, making it imperative to incorporate Internet use within basic education. There are problems to be overcome, however, and as with any working environment there are principles of good practice to be followed and conditions to be met. These important developments and concerns are addressed in the present chapter.

INTERNET USE IN SCHOOLS

Access to the Web provides a richness and variety of resources that a conventional school library cannot hope to emulate. Many of the resource sites go beyond the provision of information; they allow the learners to interact with the materials and so stimulate collaborative learning across local, regional and national boundaries. For example, the US National Aeronautic and Space Administration (NASA) Website[1] offers a suite of interactive projects. The on-line activities allow communication with NASA scientists and researchers, so that teachers and students can become involved in NASA missions and experience the excitement of science as it is happening. In the Swedish site *Science, Technics and Ethics*, students plan a simulated island environment and see the consequences of their decisions.[2]

Working with such facilities offers the potential for motivational gains, the creation of authentic project activities, cross-cultural exchanges and language learning. Some of these benefits and others are evident in the enthusiastic responses of students to Internet use:

> The online discussions are a great way to learn. Questions can be asked and answered at any time, at the students' and professor's convenience. In addition, reading other students' questions makes it possible to see what troubles other students are having – how they view or approach a problem can be unexpectedly different from one's own approach. Using other forms of media for learning is useful [to] broaden the scope of the course for more advanced students (...). Often when you work with the Internet you have to do presentations afterwards. In a way, it motivates students to deepen their study of the subjects they have chosen. The presentation can use a homepage, and to make one you need a bit of experience. If teachers can help you both with the subject and in using the various possibilities offered by the Internet, it can be rather inspiring.
>
> Participant in OECD International Student Network

One novel pedagogical model, the *Web Quest*,[3] offers enquiry-based activities in which "most or all of the information used by the student comes from the

1. See *http://education.nasa.gov/ltp/*.
2. See *http://www.knut.kks.se/not/not99*
3. See *http://edWeb.sdsu.edu/Webquest/*

Web". The objective is to develop a range of higher-order skills. Many teachers have used the *Java* programming language (Crowe and Zand, 2000, p. 131) to develop their own interactive materials, thereby facilitating complex presentations on the Web, including interactive simulations. In this way a particular concept may be conveyed through visual imagery, or an open investigative environment established, where students can explore a range of phenomena. In mathematics, for instance, a hundred and more sites offer Java programmes (known as applets), to be run on-line or downloaded.

Stimulating examples of innovation may abound, but are not typical of the education system as a whole. A US study (Becker *et al.*, 1999) showed that, while 68% of *teachers* used the Internet to find resources for use in lessons – 28% on a weekly basis or more often – only 29% of *students* used the Internet in school. This disparity might be due to a lack of connectivity, but more fundamentally may highlight the mismatch between Internet opportunities and existing curriculum requirements. Effective student use of the Internet requires teachers to be free to develop strategies that exploit the rich resources of the Web, that promote meaningful learning through communication and enquiry. Within existing structures, many teachers are doing no more than drawing additional resources from the Web in support of conventional teaching practices. For them, the incorporation of ICT may simply add stresses to an already overloaded school system.

The Internet epitomises the educational potential of ICT. It also illustrates that this potential cannot be fully realised without radical change in methodology and in the structure of the learning environment. Use of the Internet is ill-fitted to regular school periods, typically 35-50 minutes, with conventional face-to-face teaching based around traditionally-defined subjects. Where, as in Sweden, there is greater flexibility in the school day and the curriculum structure, real-time Internet-based activity is more readily possible. In Japan, a part of the week left free from defined curriculum requirements can be used for experimenting with on-line techniques.

With the emphasis it encourages on learning rather than teaching, ICT offers a flexible approach that under suitably managed conditions can be greatly responsive to the needs of individual learners. A learning sequence might start with information retrieval, an inductive process that develops critical attitudes. It goes on to information sharing and collaborative working, via e-mail or the creation of Web sites and multimedia presentations, activities that require and develop higher-order thinking skills. Traditional school-based learning, which

is more deductive, is less able to promote these skills and processes, so relevant to the contemporary world.

Two modes of use: off- and on-line

It is useful to distinguish between two educational objectives in relation to the Internet – working with the information made available on a particular site, and conducting an open-ended search. The first brings an immediacy that a textbook cannot emulate, allowing access to materials currently under development or discussion, such as topical news issues or unfolding research. The Web, however, is ephemeral in nature, and sites can be updated or modified unexpectedly, be slow to download or temporarily unavailable. If a particular site is crucial to a lesson, such unpredictability with the Internet could lead to difficulties for classroom management. One solution is for the teacher to copy the site to a CD-ROM, or to the local server, in advance of the lesson. If the interest is primarily in the subject matter, it is of little consequence whether the learner is actually on-line, or working on a copy saved earlier by the teacher.

When, however, the learning objective relates to developing the capacity for Internet search, including interactivity, there is no substitute for real-time participation and it is imperative to be on-line. The necessary skills will include being able to deal with or circumvent the problems of slow download or unavailability, by finding and engaging in alternative stratagems. Specific information-handling skills are needed, including an understanding of electronic indexing, to engage in the often complex routines for locating relevant and appropriate materials from the Web. Learners in this environment can find themselves accessing segments of documents from different sources and at different levels of interest or sophistication. Judgements are needed about the appropriateness of the level, the relevance of the source and its reliability, and part of the learning objective will be to develop skills in these areas.

Whatever the objective in using the Internet, there are challenges to the teacher. Too easily in searching on a topic, a student performing an Internet search might download materials and paste them together, with no particular engagement nor gain in understanding. The challenge here is to pursue the development of the desired higher-order analytical and presentational skills – a necessary element within digital literacy – while avoiding the surrogate of a cut-and-paste alternative. It may be easier for the teacher to manage the activity of working directly with a specified Web site, but it implies considerable lesson

preparation – locating, perusing and downloading the site, and deciding how to use it. There is a contrast with the relatively straightforward and predictable use of well-tried printed texts and materials. The extra work is justified when it brings *added value* to the learning experience, the novelty or currency of the Internet site compared with available alternatives.

Local Web sites

The facility for schools or individual students to create their own Web sites is a powerful motivator. It provides a unique forum for low-cost quality publication, to stimulate communication between schools, students, parents and others. As was noted earlier (Chapter 3), the same facility is available to promote the activities of any interest group, including speakers of little-used languages – the vast unstructured Web provides the means of rich development for minority interests. Facility with this technique becomes a notable aspect of digital literacy, and of central importance to the lifelong learner. A student saw such Web sites as a natural development from the use of e-mail for collaborative learning:

> I used my e-mail a lot when our school in the Netherlands had an exchange project with a school in Russia, using English (the second language we had in common). We made a 3-D world with our school and a museum, having received all the museum information by e-mail (...). The future intention is to make Web sites open to everyone, instead of using e-mail, to allow working together with schools all over the world.
>
> Participant in OECD International Student Network

Publication on the Internet may also contribute to student assessment. In Norway a course on *Pedagogy in Open Learning* includes compulsory work for each learner which is assembled in electronic workbooks on the Web. The contribution of an individual student is available to others, as part of a scheme of collaborative learning (Norway, country note). Teachers likewise use Web publication to produce and distribute their own teaching resources. In Ireland the ScoilNet education portal developed Web publishing wizards to make this easy (Ireland, country note). Italy and the United Kingdom encourage such production of materials by competitions and awards (Italy and the United Kingdom, country notes). The Dutch Knowledge Net is intended for use by *every* school student – primary to secondary – and *every* teacher and headteacher.

There are dedicated domains within the site for students, teachers, headteachers and also one for parents:

> Over 2.5 million people will be using the Knowledge Net in a year's time [end of 2001]. Each one will have a unique log-in name that gives them access to the Knowledge Net 24 hours a day, seven days a week (...). Every user can construct a Web site where he or she can place information suitable for use by other teachers and/or pupils.
>
> Netherlands (2001*b*)

Numerous competitions encourage Web publication by schools. One such is conducted by ThinkQuest,[4] a non-commercial organisation. Competing projects are produced collaboratively by groups of students in different countries, who work together using the Internet. They present the outcomes of their joint work as a Web resource, which continues as a reference available to others. Projects like this engage learners in high-level work and in cross-cultural collaboration. Care is needed, however, to ensure that the benefits of participation are not confined to the most able students, or the most computer literate.

- *As an abundant source of information and as a means of communication/ interaction, the Internet opens up unparalleled possibilities for learners. Dominant curricular and organisational forms were not designed for the Internet age, and often inhibit its effective use, so capitalising on Internet's potential may well mean radical changes in school structures and methodologies.*
- *Searching on the Internet requires and promotes information-handling skills, knowledge about the Internet, and the capacity to make judgements about relevance and reliability; these are important aspects of digital literacy. Informed judgements are needed about the value this adds, compared with alternative forms of learning for students and teachers.*
- *Schools and students can be powerfully motivated by developing their own Web-sites, to become important channels of communication – within school, between schools, students, parents, and others – and to contribute to student assessment.*

4. See *www.thinkquest.org*.

INTERNET ACCESS AND CONNECTIVITY

Schools with reliable and always-available access – not all are in this position – often find the Internet to be more robust, flexible and easily managed than other electronic resources. Many schools have no access, or one station only. Most countries see improving Internet connectivity as an important element of national ICT programmes, but with widely varying financial commitment (Pelgrum and Anderson, 1999, p. 219). Secondary schools frequently have a higher level of connectivity than primary schools. The table shows the percentage of schools using the Internet across a range of countries as it was in 1998-1999 (but even then changing rapidly):

Country	Primary	Lower secondary	Upper secondary
Belgium (French)	n.a.	41	59
Canada	88	98	97
Czech Republic	n.a.	33	68
Finland	87	96	n.a.
Iceland	98	100	100
Italy	28	73	73
Japan	69	58	50
Luxembourg	n.a.	79	76
New Zealand	77	89	n.a.
Norway	56	81	98

n.a.: not available.
Source: OECD (2001*a*).

Traditionally there have been two types of Internet connection. One option, typically used by large institutions such as universities, is a *permanent dedicated channel* that affords Internet access at all times, usually on an annual lease basis from a telecommunications company. More familiar to the home user is the *dial-up connection*, whether using an ordinary telephone line, or an Integrated Services Digital Network (ISDN) line, that carries information at higher speeds. The cost in these cases is normally related to the amount of time the line is connected. Telecommunications companies are, however, introducing the Asynchronous Digital Subscriber Line (ADSL), which will provide home users with an always-available high-speed Internet connection at a much lower cost than a leased line.[5] In competition with this technology, cable television operators are beginning to offer Internet access through their lines.

5. See *www.adsl.com/*.

Bandwidth

A key variable in Internet access is the capacity or *bandwidth* of the connection, which measures the speed at which data are transmitted.[6] High bandwidth is necessary, not simply for rich multimedia content and significant levels of interactivity, but when several computers share one connection, even for relatively unsophisticated applications. Schools differ in the type of connectivity available to them, and therefore in the extent to which they can make use of Internet facilities. Increased and more sophisticated Internet use within school both *requires* higher bandwidth and *generates* increased demand, as more complex sites become accessible and faster response times stimulate usage.

Canada reported that bandwidth often cannot keep up with demand (Canada, country note). Although the cost of bandwidth is falling, school demand is rising at a faster rate. In parallel with improved school access, higher bandwidth is needed for the *suppliers* of the educational resources used in school, such as museums, libraries and universities. This need is recognised in some national strategies, for example the UK, where the National Grid for Learning envisages a "networked learning community" including schools, colleges, libraries and museums (Selwyn, 2000). How the necessary improvements in connectivity and bandwidth might be achieved is of particular concern to governments.

The cost of being on-line

In a small number of countries education authorities fund the cost of Internet access. This is the case for Belgium (French Community), Luxembourg, most jurisdictions in Canada, and for secondary schools in Portugal. Telecommunications providers in many countries have been responding with low fixed-cost packages for education users, as in the United Kingdom (country note) and Norway (country note). The US Schools and Libraries Support Mechanism, popularly known as the "E-rate", provides discounted Internet access, internal connecting, and telecommunications services to schools and libraries. The discount is 20%-90%, according to the percentage of students eligible for a National School Lunch Programme, with a more generous scale for rural areas. E-rate support for schools is running at the rate of around $2 billion annually.[7]

6. Typically, a dialled-up connection will be 64kb/s or less, ADSL up to 8Mb/s one way and 1Mb/s return, and cable modem TV up to 30Mb/s, shared between multiple users.

7. See *http://www.universalservice.org/reports/2000/pg4.asp*.

Ireland, where all schools have Internet access, has an hour a day of free connectivity from Eircom (country note). An Australian study noted that "the education and training sector is one of the largest users of telecommunications bandwidth in Australia, but needs adequate access to bandwidth at competitive price, if it is to exploit the potential educational benefits" (country note, *b*). Some bandwidth issues may be reduced by the emergence of higher capacity and the always-available connectivity options offered by ADSL and cable modem TV. As yet, however, concerns about costs and their unpredictability often remain a barrier to school Internet use. There is a need for continuing dialogue between governments and the other parties concerned – the industry, the regulatory authorities and the schools.

The Internet is an equaliser of distance for those who are connected, since the cost of receiving material is the same from the other side of the world as from the next town. Nevertheless, geographical location may still be an issue. Cable modem TV, for instance, is often restricted to urban areas. The telecommunications link between the Internet and the school is likely to be more expensive for geographically remote schools. This *last-mile cost* may be particularly severe for high bandwidth connections. Uneven Internet access raises another example of the digital divide where some sections of society are denied the benefits others enjoy.[8]

A range of emerging low-cost devices will allow the Internet to be displayed on a television set, thereby providing whole-class participation without computer or data projector. Levels of connectivity could rise yet further with wireless Internet access becoming available for every student. As yet, however, these routes offer no more than "read only" rights to multimedia content. Access to information is valuable, but learners benefit most in an interactive environment in which they can generate knowledge (see also Chapters 2 and 3).

- *Internet access for schools has increased dramatically but the situation remains far from ideal. There is still a widespread need for more work stations and higher bandwidth, to promote wider and more sophisticated use.*
- *The cost of being on-line can be a severe deterrent to Internet use in schools. Technological advances will partly alleviate the problems, but government action can prove essential. It is an area calling for imaginative solutions and continuing dialogue between governments, industry, regulatory bodies and schools.*

8. See OECD (2000), *Learning to Bridge the Digital Divide*, Paris.

EVALUATION OF EDUCATIONAL RESOURCES ON THE WEB

Compared with other use of ICT in education, there are extra factors to be considered when evaluating Web-based resources. Some of these are technical, and relatively easy to address, as the following checklist suggests:

- Does the server respond quickly and reliably?
- Does the material appear without errors on standard browsers (current HTML standards)?
- Does the site contain non-functional hyperlinks?
- Is the size of embedded files – especially graphic, audio and video – appropriate, to avoid excessive download time?
- If the site offers teacher materials for downloading, is the file format standard – RTF, PDF, JPG, etc. – and its size indicated?
- Are text alternatives available for pictures and graphic representations used for navigation purposes?
- Is additional software (plug-ins) required, and if so are there references to Web sites from which they may be downloaded or information about them obtained?
- Do embedded Java elements (applets) comply with the usual standards, for error-free use in modern browsers?
- Does the material describe all technical requirements – recommended browser, necessary plug-ins, Java activated, etc.?
- Is it possible to download the material for use off-line?

Based on Weber (1999*b*)

In respect of issues of content and methodology, the situation is much more fluid and less open to precise evaluation. When digital content is in the form of a diskette or CD-ROM, contents and pedagogical strategies can be reviewed relatively straightforwardly. In so far as similar materials are obtained from the Internet, and the change is merely in mode of delivery, the content, pedagogy and use can be evaluated as before. More often, however, resources on the Web will offer large volumes of content capable of being accessed in numerous sequences and combinations. It may be practically impossible to view all the material within a single Website. In the search for quality, account must also be taken of the transient nature of the Web. Even if a site were to be formally

evaluated, it might in a short period evolve dramatically, thereby negating the credence of any judgements on it already made.

The teacher – and increasingly the student – must approach Internet use with an ability to make qualitative and discriminating judgements. The concept of quality will be based on their previous learning and use of ICT, and for some teachers this will include experience of evaluation of digital content (see Chapter 5). For government- or university-run sites, for instance, there may be an initial presumption of reliability, but it will still be necessary to judge the appropriateness of the materials and methodology. When sites of unknown provenance are visited, judgements of quality will have to be made as the resources are revealed, with no prior assumptions.

Quality standards used to evaluate specific items of digital content may be inappropriate for the open-ended and constantly developing nature of some Web sites. A site that follows the journey of an Arctic scientific journey, for instance, may attract thousands of learners to take part in virtual travel and exploration as the events are unfolding. The teachers and learners will have to exercise their own judgement about taking part – and continuing to be involved – in terms of expectations rather than firm evidence (Jones, 1999).

Where the technology is used to provide a medium for communication between learners, different quality concerns arise, since much of the content develops *during* the dialogue. The educational value derives partly from the processes that it supports, so to that extent evaluation will be concerned with the quality of the learners' interactions with each other and their teachers – the fluency in finding, handling and assessing information. Vaille (quoted in Jones, 1999) suggests that a key to quality in on-line learning is the extent to which an *Internet learning style* is fostered. This is an interactive, participatory and collaborative style that permits the sharing of ideas and experiences, that facilitates independent investigations as well as co-operative group work, that encourages learners to explore the Internet's resources and to create new relationships.

Given the fast moving and ephemeral nature of many Internet-based activities, the focus of quality assurance will have to move towards empowering teachers and learners to make their own judgements as required. They will often be generating content as they interact with each other, so it may be advantageous to identify criteria by which they can evaluate their own performance and achievement. This shift to self- and group-evaluation is a marked departure from earlier forms of purportedly objective software evaluation. It forms an important part of the *life skills* agenda for the knowledge society.

- *Evaluating Web-based educational resources calls for attention to technical factors but these are relatively straightforward. It is in the content and methodology that evaluation of these materials becomes much more fluid and complex.*
- *Given its fluidity, the focus for quality evaluation of Web-based resources shifts towards empowering students and teachers to make their own judgements. Where the educational value depends on interactions among learners and teachers, the evaluation must take account of this, which leads to the concept of an "Internet learning style" – interactive, search-oriented, collaborative but with individual autonomy.*

NAVIGATION, SECURITY, MISUSE

Several concerns arise in connection with Internet use in education. One is the sheer volume of resources and projects, with an unregulated structure and no single indexing system. Available content relevant to any curriculum topic will quickly go beyond what is useful to a student engaged in a particular task. Another concern is the wide variation in quality. In common with other media, the Internet carries material that is not suitable for educational purposes. The enormous resources can just as easily include propaganda and questionable materials as those for enrichment and democratisation. The sensible response – as with other media – is not to ban, but for students to learn how to use the Internet with discretion and developing moral awareness.

The *search engine* is a tool that can be used to locate Web sites and materials, using key words and other indices, though sometimes with a lack of discrimination. To help the search process, sites may include codes hidden from the reader, but intended to describe the topic of the page and therefore to aid selection (known as *meta-data*). Certain navigational skills are necessary if a search engine is to be used effectively. Users must learn to search systematically on a theme or topic, and be able to locate the best material within much of indifferent quality. They must become discriminating and discerning, capable of reflecting on the reliability and credibility of a site, and ready to reject what is inadequate and unsuitable.

The use of search engines is not without its problems. To enhance their chances of being visited, sites of dubious worth may disguise themselves, deliberately adopting words in normal use within a perverse context. They may manipulate their meta-data to the same end, so that innocent searches are unwittingly led astray. Sometimes searches will lead to sites which no longer

function, or which have become infiltrated by undesirable materials. They may become channelled inexorably towards electronic commerce and demands for credit card numbers. Problems for education arise because of the pervasive presence on the Internet of commercial advertising, which can intrude into the classroom and may even be targeted at the classroom.

Mindful of the concerns about Internet use, some countries have produced policies to guide learners in their approach to the selection of Web materials. Ireland has distributed *Acceptable Use Policies* to all primary schools. In the United Kingdom an information pack *Superhighway Safety: Children's Safe Use of the Internet*, provides guidance to schools on the measures needed to ensure that children use the Internet advisedly[9] (country note). Moreover, the government has set up a facility *Gridwatch*[10] that "enables action to be taken to exclude inappropriate materials from the Grid". Some countries, including Ireland, Canada, Belgium (French Community) and Sweden use filtering software in an attempt to prevent exposure to undesirable materials. Such filtering works by blocking either proscribed sites, or sites which incorporate particular traits, such as key words. Many filters use a combination of both, but even so the technique is relatively primitive and unreliable. Unwanted sites repeatedly change their names, or specifically avoid sensitive words that might be used to identify them. Conversely, filtering by key words is likely to block legitimate sites – for example those dealing seriously with medical issues – for inappropriate reasons.

The Internet Content Rating Association[11] was established "to protect children from potentially harmful material while protecting the free speech rights of content providers". It is an independent, international organisation representing many of the major corporations in the industry. Without itself offering value judgements, it encourages voluntary self-classification of Web resources using meta-data. Authors describe what is, and is not, present in their sites, in terms of factors such as language, levels of violence, suitable for "adults only". The resulting open and objective labelling of content is designed to inform parents and others. It enables them to make informed decisions about Internet use, with blocking mechanisms that disallow access to sites if they so choose.

The *walled garden* is a mechanism that allows students access to a limited selection of Web-based materials, kept free from anything undesirable.

9. See *http://vtc.ngfl.gov.uk/vtc/library/safety.html.*

10. See *http://www.ngfl.gov.uk/grid_safety/detail.html.*

11. See *http://www.icra.org/.*

Frequently this necessitates access to the Internet through a specific service provider, which has infrastructure implications as not all schools will be able to use it. By confining browsing to a small selection, it gives no scope for developing the important search-and-discriminate skills necessary for unrestricted Internet work.

Educational portals

An extension to the *walled garden* is offered by *educational portals*. These are sites that provide routes into Web resources that have been selected by an intermediary agency, in which teachers and learners can have confidence. There remains, in this case, freedom to follow up hyperlinks and therefore to browse outside the selected materials. Examples of portals are the Northrhine-Westfalian Educational Server *learn-line*,[12] and the Irish *ScoilNet*.[13] These portal sites offer direct links to a considerable range of materials relevant to the curriculum, usually chosen through the mediation of teachers. In addition, *learn-line* stimulates co-operation between users and developers within a supportive educational environment.

The portal process is one of selection and classification, rather than evaluation, from reliable sources and from stable and well-supported Web sites. Value is added where there is the opportunity for professionals to exchange ideas and observations on the materials. The selections are made *on behalf of* learners and teachers, and because much irrelevant material is eliminated, searching can be more precise and effective. As teachers gain experience, they will use a portal with the same confidence as they would the catalogue and products of a reliable book publisher, and encourage their students to do so. Portals are being developed extensively across Canada, for instance the *Alberta On-line Curriculum Repository*, in Australia and elsewhere.

The *Link Larder*,[14] part of the Swedish *Schoolnet*, is a portal designed mainly for students aged 10-15. It offers Internet information classified by subject, that has been selected *and evaluated* by subject editors, who are experienced teachers or school librarians. With a wider remit, the UK *National Grid for Learning* portal is perhaps the biggest in Europe. It "brings together a vast and growing collection of sites that support education and lifelong learning",[15] and allows

12. See *http://www.learn-line.nrw.de.*

13. See *www.scoilnet.ie.*

14. See *http://lankskafferiet.skolverket.se.*

15. See *http://www.ngfl.gov.uk.*

access to an educational software database containing many hundreds of entries, for subjects across the curriculum.[16] On this scale, there is no attempt to provide independent evaluations, but a readiness to identify reviews made elsewhere:

> Information contained within this database has been provided directly by software publishers, and each of the product records may contain an outline of system requirements, formats, networking options, a description of the software and references to reviews in the professional press. Where available, we have also linked to reviews of the product on the TEEM (Teachers Evaluating Educational Multimedia) Web site.
>
> NGfL – *http://besd.becta.org.uk/*

While portals may commission Web-based material, their central role is to be the intermediary between suppliers and users of materials. Their function is to impose order on the Web, presenting the relevant parts of it to busy teachers and learners, thus facilitating effective choice within available resources. The work of a portal is therefore to find materials, to select those judged to be suitable, and to organise them in a way that matches curriculum structure.

The European Schoolnet, EUN, may be described as a *super-portal*, since it is linked to many national portals. Within EUN the European Treasury Browser[17] is being developed, to offer multilingual search services in a common format throughout the site. It will promote the sharing of educational materials across Europe, whilst safeguarding original editorial control. The priority is to make available classified educational resources of quality. When, however, a super-portal carries tens of thousands of links, it becomes necessary to have search facilities to guide navigation within the site. Such a portal becomes equivalent to a search engine restricted to one subject – education – so the boundary between portals and search engines becomes blurred. The incorporation of meta-data – that allow sites to be classified in terms of the subject, level and type of approach – is a key necessity for rapid and accurate automated searches.

16. The database is maintained by the British Educational Communications and Technology Agency, see *http://besd.becta.org.uk/*.

17. See *http://www.en.eun.org/eun.org2/eun/en/etb/content_frame.cfm?lang=en&ov=6463*.

- *The volume of Web-based materials is vast and the contents often inappropriate. The effective use of search engines to locate suitable sites and topics calls for navigational skills and discriminating judgement.*
- *A variety of mechanisms – filters, simple selections (the walled garden) and classifications (such as "adults only") – have been developed to reduce access to undesirable sites, but each has its own limitations.*
- *Educational portals select and classify educational materials to enable more purposeful searching. When they become very large, it is impractical for them to offer independent evaluations, but the more they permit feedback from users and descriptions of actual classroom use, the greater is their value to teachers and students.*

CHAPTER 5

THE PRACTICE AND PROFESSIONAL DEVELOPMENT OF TEACHERS

Teachers – with a changed and extended role – are central to the way ICT is adopted and used at the classroom and student level. The supposition that teachers might be displaced by the technology has been largely discounted, even though the media and popular opinion seem still to characterise the technology as valuable independent of teachers. Not only does this fail to understand the key role of the teacher in using ICT in schools, but by dis-empowering the teacher and stressing the technology, it undermines the educational potential of the technology itself (Selwyn, 2001). Parents may fail to support radical school reform, supposing ICT to be no more than an operational skill to be taught for vocational purposes. They see young people who feel comfortable with a mouse, a keyboard and a screen, and perhaps conclude too readily that they have the capacity and motivation to learn independently through ICT.

This chapter indicates how ICT both demands and facilitates a broader, more challenging view of teacher professionalism. It discusses the critical area of teacher professional development, both initial and in-service. If the educational investments in ICT are to reap the rewards expected of them, this must be the focus for sustained policy action. The chapter concludes with the views expressed by the students in the OECD network. They are convinced of the importance of the teacher role, and the positive impact this has when the system is supportive

and everything is working well. They offer remarkable examples of the power of ICT to transform the learning environment. It is salutary also to note their criticisms of schools and teachers when the use of ICT is not wisely planned and effected.

TEACHER ROLES AND PROFESSIONALISM

The teacher must play a central and crucial management role regarding ICT in schools. Apart from certain limited applications available through *closed* software systems, as discussed in Chapter 3, the *open* applications of ICT introduce a dynamic, interactive environment that is likely to require more routine planning, preparation and one-to-one intervention than that needed for traditional curriculum delivery. The teacher becomes manager of the learning environment – a creative, interesting, demanding and professionally rewarding role.

> The teacher functions more as a tutor and facilitator, less as a lecturer. The teaching is more individualised, the move from whole-class teaching – that was already on its way – has accelerated.
>
> Sweden (country note)
>
> In the Netherlands, we can see a slow, but steady, change from traditional, teacher-centred education, to more richly differentiated learning environments in which the role of the teacher is becoming more supportive. The adoption of ICT in schools stimulates this change.
>
> Netherlands (country note)

This expanded role for the teacher in a changed learning environment has considerable resource implications, in terms of staffing levels and professional development needs. Teachers will need to be able to modify their pedagogy dramatically and on a continuing basis, whereby they will become for their students role models for lifelong learning. This will not be widely attained without major and sustained commitment, and cannot in itself – as often supposed – lead to significant educational cost saving. Rather it offers the prospect of a better-quality and more inclusive learning environment, but crucial to this is the digital literacy of the teacher, the teacher's levels of ICT skill and understanding.

Teachers' pedagogical beliefs play a central role in the adoption of ICT. For the most part they incorporate ICT in the first instance by adopting those elements that serve their existing teaching style, rather than entirely changing to match

the opportunities the technology may offer. A long-term study of the impact of the Education Superhighways initiative in schools in England and Wales showed that teachers with Internet access tended not to alter their pedagogy dramatically; but did better what they had done before (McFarlane and de Rijcke, 1999). Meaningful integration of ICT beyond this threshold level involves changing teachers' beliefs, and is inevitably a time-consuming and complex process (Niederhauser and Stoddard, 2000). It takes time and resources for teachers to become knowledgeable about technology and confident enough to use it effectively in the classroom. This adds to the demands upon teachers, going well beyond ICT skills *per se*, and extending to the transformation of pedagogy, for the full educational potential of ICT to be exploited.

As we discuss in the next chapter, ICT opens up professional roles in other ways by breaking down traditional notions of school boundaries and teacher expertise. Teachers must be comfortable when working with students whose ICT skills surpass their own. A dynamic classroom will often combine materials produced by the teachers and learners themselves with those provided elsewhere – possibly on a commercial basis. For this to happen, favourable circumstances have to be created, through interaction between the makers and suppliers of educational software and their clients, the students and teachers.

Teacher networking and co-operative practice

New channels of communication are opened up by ICT, to take teachers beyond the classroom confines, as they engage in electronic dialogue with colleagues inside and outside the school system, and with parents, ICT suppliers and the wider community. This move from an individualistic and isolated concept of teacher professionalism has been identified as a prerequisite for schools to become *learning organisations*, as argued in the OECD analysis of knowledge management in education:

> At the level of the individual teacher, there needs to be a psychological transition from working and learning alone, with a belief that knowledge production belongs to others, to a radically different self-conception which, in conformity with interactive models, sees the co-production of knowledge with colleagues as a natural part of a teacher's professional work. At the system level ways have to be found to bring teachers together in such activity. OECD (2000*b*), p. 74

ICT offers manifold possibilities to encourage such corporate working, but the conceptions of professional activity held by teachers shape the nature of the introduction of the technology into schools. According to Riel and Becker (2000), the extent of teacher-to-teacher discourse is linked with the way that ICT is adopted. They classify teachers on a continuum of professional engagement, from *private-practice teachers* – who engage in little dialogue or activity beyond the classroom – to *teacher leaders*, who place a high value on sharing with colleagues. In a survey of 4 000 US teachers, the teacher leaders consistently proved to be better educated, continuous learners, and computer users, who promoted student-centred methods. Those teachers who had many professional contacts with other teachers at their school were three-and-a-half times more likely to employ a strong knowledge-construction approach to learning than teachers with few contacts (CRITO, 1999*a*).

It is to be expected that teacher-to-teacher contact will be important in the diffusion and development of methodology. Teachers who engage in dialogue with colleagues are likely to value the views of other teachers, and accept their experiences as valid. The importance of peer views is highlighted in a US study (NCES, 2000): although teachers cited independent learning most frequently as preparing them to use technology (93%), this was closely followed by professional development activities (88%) and exchange with colleagues (87%). Such dialogue between practitioners is a mark of professionalism. The opportunities for teachers to engage in it are considerably enhanced by ICT.

E-mail communication between teachers has been slow to develop, reflecting traditional styles of working in relative isolation, with low levels of collaboration and sharing of ideas. A survey of US teachers in Spring 1998 showed that only 16% had conducted a regular e-mail conversation with a teacher in another school (CRITO, 1999*b*). Even among teachers who make high use of ICT, only a small proportion report increases in collaboration between teachers (Pelgrum and Anderson, 1999, p. 224). The *Northern Ireland Network for Education* provides conferencing spaces for teachers to discuss ideas and methods; use of this facility is now a required part of their initial period of training and practice.[1] Projects such as IBM's *Wired for Learning* aim to use Internet communications to strengthen links between home and school. Even when the communication networks are in place, however, it cannot be assumed that teacher-to-teacher collaboration will develop without encouragement.

1. See *www.nine.org.uk*.

- *Teachers are central to the successful use of ICT for school learning, in any realistic and comprehensive awareness of its huge and complex educational potential. The teacher becomes manager of the ICT-enhanced learning environment – a creative, stimulating, demanding and professionally rewarding role.*
- *Dialogue among teachers is increasingly apparent and desired, with a widespread move away from the traditional individualistic and isolated modes of operation. ICT offers manifold possibilities to encourage such corporate activity, which will promote the development and dissemination of successful learning strategies and a sharing of expertise.*

TEACHER PROFESSIONAL DEVELOPMENT

Initial professional development

The initial teacher education curriculum is often crowded, and scarcely offers space for more activity. Even so, ICT is increasingly being introduced as an element in the initial professional development of teachers. In some countries ICT skills form a compulsory component of teacher education, but in other cases it is left to the discretion of the individual institution, or made an optional part of the programme. In one instance, the Netherlands (country note), teachers are required to obtain the *European Computer Driving Licence,*[2] devoted to ICT skills – word-processing, presentations, the World Wide Web and e-mail. A number of countries expect beginning teachers to have developed *both* ICT skills *and* pedagogical insights for their effective use.

Canada sees many teacher-training institutions striving to balance the pedagogical implications of ICT in pre-service programmes with the need for student-teachers to learn about curriculum, teaching methods, and classroom management (country note). Norway incorporates 25 hours of instruction, guided practice and self-study devoted to ICT in the first year, after which it is an integral part of pedagogy, methodology and subject content. Subsequently, many institutions offer popular elective specialist courses in ICT, in which about half of the content relates to pedagogy (Norway, country note).

2. See *http://www.ecdl.com/index.html.* By June 2001, one million people world-wide had taken this.

An optimum balance between operational skills and an understanding of the pedagogical implications is difficult to achieve. First, however, a starting low level of technical skill among student teachers must be remedied, both because it will be a barrier to classroom use and because the pedagogical implications will make little sense without some technical competence. While initial teacher education cannot go very far in equipping teachers to evaluate educational materials or to analyse learning processes, beginning teachers need some basic pedagogical frameworks within which they can readily and enthusiastically accommodate ICT. With a good basic understanding of pedagogy, they will subsequently be able to refine their own methodology and judgement related to ICT, as they gain experience and as the technologies advance.

New-entry teachers often now bring with them a certain level of ICT expertise, whether acquired as part of their initial qualifications or through other personal experiences. Many are likely, however, to encounter senior colleagues who are reluctant to change long-established techniques, in favour of unfamiliar and unproven ICT approaches. Especially this will be so where the trusted techniques are associated with a record of success (for instance, in public examinations). Those on teaching practice may wish to introduce ICT, but find little opportunity to innovate without the encouragement of established colleagues. This indicates the importance of the informed and committed support of the school management, as discussed in the next chapter.

In-service professional development

Japan acknowledges the desirability of all teachers being able to use ICT, while recognising the wide variation in ICT skill levels among them (country note). In pursuit of such an aim, and if ICT is really to make an impact on the nature of school learning, *in-service* professional development is crucial. The scale of the task is, however, daunting. In the majority of OECD countries, most teachers are aged 40 or more (OECD, 2001*a*, p. 210). They joined the profession at a time when there were few computers in schools and little awareness of their potential, so apart from personal initiatives they have no background in ICT. Thus it will often happen that the senior and most influential posts in schools are held by teachers who are not themselves digitally literate (see Chapter 6). The number of teachers is very large – and accounts for the bulk of school expenditure – so the costs of providing significant professional

development for all teachers are considerable. In its current programme for implementing ICT in schools, Norway surveys the scale of the need:

> A survey (...) in January 1999 shows that half the teachers had participated in courses concerning the use of ICT tools such as spreadsheets, word-processors and the Internet. Less than 20% stated that they had received training in the use of ICT as a pedagogical tool in actual teaching. Four out of every five teachers said they needed such training.
>
> Norway (2000)

There are few direct incentives for teachers to develop expertise in ICT. Whilst to do so *may* help their prospects of promotion, for a considerable number the motivation arises from their own professionalism: they sense the importance of ICT for their schools and students, in direct relation to its widespread adoption in society. Encouragingly high levels of take-up of training in some countries, and the burgeoning demands being placed on support and advisory services, indicate the level of interest. Experience in Norway over recent years (country note) may be typical of other countries. Initially, young male teachers tended to be the first to introduce ICT into their teaching. In time, women became as keen and interest spread across all ages and all curriculum subjects, including music and physical education. This advance was helped by the greater versatility and user-friendliness of the technology with passing time.

Short in-service courses are often attended by teachers on a voluntary basis, and have been enthusiastically welcomed. Thus, during the 1997-98 school year, more teachers in the US chose to undertake professional development related to computer use than other in-service courses (CRITO, 1999*a*). In Belgium (French Community), in-service training in ICT is highly recommended but not compulsory (country note). Most schools in the Netherlands have included ICT training in their policy documents, but only a small proportion have implemented training of all teachers (country note). Even though every teacher were to attend a short in-service development course, it is unrealistic to suppose that any such one-off intervention could suffice. Given the speed of innovation in technology and methodology, teacher development must be viewed as an ongoing and integral part of professional activity (NCREL, 2000).

In the United Kingdom, £230 million has been allocated for a four-year scheme that began in April 1999, to enable serving teachers to reach the level of

ICT capability now expected of newly-qualified teachers.[3] This is still only the equivalent of a little under £500 per teacher, however, and a much smaller proportion of the technology cost than would be expected in a commercial environment (Selwyn, 2000). The scheme, focused on classroom use and conducted in the classroom whenever possible, has precisely-defined aims and is offered by approved suppliers:

> The expected outcomes for teachers include ensuring that teachers know:
> - when, when not, and how to use ICT in teaching their subject;
> - how ICT can be used in teaching the whole class;
> - how ICT can be used when planning, including the use of ICT for lesson preparation and the choice and organisation of ICT resources;
> - how to assess pupils' work when ICT has been used; and
> - how ICT can be used to keep up-to-date, share best practice and reduce bureaucracy.

The programme from one such supplier[4] starts with an induction day for the subject department, science in this case. Each teacher receives 36 fully-prepared lesson outlines matched to the national curriculum, in which ICT is integral, including background information and help sheets. Many of the lessons incorporate complementary software showing simulations, data analysis and modelling. Selecting from these materials, every teacher has to teach six of the lessons over a year, each followed by an evaluation sent to a personal on-line tutor. In addition to iterative support from the tutor, help is available from a Web site and another visit may be arranged to the department.

UK teachers who registered for one of these approved ICT courses became eligible to participate in a *Computers for Teachers* purchasing discount scheme, that was introduced in 2000 and subsequently extended for a further three years with increased funding.[5] A number of countries have introduced similar schemes. The Netherlands allows a teacher to buy a computer at a reduced price (country note), and every teacher in Sweden who takes part in the national in-service training programme is given a computer (country note). This approach provides teachers with the equipment needed for lesson preparation and research, while

3. The *New Opportunities Fund*, see *http://www.canteach.gov.uk/info/ict/nof/index.htm.*

4. See *www.scienceconsortium.co.uk.*

5. See *http://cft.ngfl.gov.uk/.*

at the same time stimulating the teachers' development of digital literacy by encouraging home use.

Engaging the entire staff of a school in thinking about ICT at the same time may offer considerable potential for facilitating classroom change. Greece is an example of a country using a *cascade* model (country note), whereby selected teachers follow university courses in both technical and pedagogical issues, and subsequently share their experience with colleagues. The approach is novel in that it goes on throughout the year, is school-based, and counts the teachers as co-developers. Courses involve dynamic participation to develop computer-based projects related to school and community needs.

In Canada, the requirement to be able to demonstrate ICT competence varies across jurisdictions, but demand for courses generally exceeds the available supply (country note). Some Canadian schools form their own school-based ICT learning communities, to facilitate ICT integration and professional development. Each teacher outlines a personal ICT professional development plan, the response to which identifies forthcoming in-service training, online resources, courses, and staff mentors who may be able to help. Regional expertise networks are being developed in the Belgian Flemish Community (country note), intended for all kinds of co-operation. In pursuing their basic purpose – to provide in-service training, along with technical and organisational support – the networks identify and use already-existing ICT expertise amongst teachers.

There has been a phenomenal uptake for 20-hour courses developed in Ireland by the National Centre for Technology in Education, covering ICT skills, classroom pedagogy and subject-specific issues (country note). Many teachers complete a course – on a voluntary basis outside school time – and return for a second or third. Additionally, a number of third-level institutions have begun to offer teachers diploma and master's degree programmes in ICT in recent years. Increasingly such courses incorporate research into school-based projects, as well as the opportunity for in-depth study of current thinking on the educational implications of ICT. They provide a further stimulus for change.

The Irish National Centre for Technology in Education maintains that teachers should themselves possess the skills to decide if a particular piece of educational software is suitable. In pursuit of that objective, it adapted the TEEM framework (see Chapter 3), *both* to establish teams for software evaluation *and* to be a component of all relevant in-service ICT courses. The development was piloted over a ten-month period, with more than one hundred teachers receiving training on using the evaluation framework. Following modifications

arising from the pilot, classroom evaluations of two hundred digital-content items were planned for 2001, with a Website *Software Central* to be developed for giving access to the findings. The framework is to be expanded to include content-free software and the World Wide Web.

Within in-service activities, Irish teachers learn how to use the TEEM-based evaluation framework and have an opportunity to evaluate educational materials. The Irish teaching profession has embraced the evaluation process, which augments their capacity for professional judgement and empowers them to make key decisions regarding the learning environment for which they exercise responsibility. Software publishers are also supportive and have provided evaluation copies of their materials to all evaluators. Multiple copies of a summary booklet[6] have been freely circulated to all colleges of education and university education departments. Many faculties are integrating the approach into existing courses and providing a copy of the booklet for all new teachers. It seems entirely appropriate that ICT, which is the *object* of professional growth, can at one and the same time provide the *medium* through which such growth is achieved, in collaboration with colleagues and other partners.

- *Increasingly, ICT is being introduced into the already-crowded programmes of initial teacher education. In the first instance, the aim is to equip beginning teachers with key ICT skills, relating to word-processing, multi-media and presentations, the Web and e-mail. More ambitiously, some systems also want beginning teachers to have addressed strategies for using ICT in their teaching.*
- *For ICT to make a genuine impact on the nature of school learning, in-service professional development is crucial. As education is such a large, labour-intensive sector, the costs of ensuring this on a continuing basis for all teachers are considerable. Such investments must be made, however, as without them the strategies for effective technology integration into schools cannot succeed.*
- *Promising approaches to in-service development include providing teachers with subsidised or free ICT equipment, and the development of whole-school strategies. It may be especially fruitful when ICT is both the object of professional growth and the medium through which it is achieved. Despite a lack of incentives for participation, some programmes have enjoyed overwhelming popularity.*

6. NCTE (2001), *Evaluating Educational Software: a Teacher's Guide*, Dublin.

TEACHERS AND ICT THROUGH THE EYES OF THE STUDENTS

In probing the practical realities of how ICT has been introduced to education, its effects, and potential – realised and unrealised – whom better to ask than the students themselves? Those who have passed through secondary school over the past decade have lived within these changes and have first-hand experience of the developing use of ICT in the classroom. Unlike their teachers – and their parents – they take computers for granted and generally know more about them. Often, it is they who take the lead at home when it comes to choosing computers and other equipment. Many have the imagination and vision to see what could be done with ICT to make dramatic changes in the possibilities for learning. They have the fresh perspective of the young to observe critically what has been and is being done, and are frank in their observations.

The student criticisms seem often to focus on teachers, but should more properly be seen as directed to the system, within which teachers can only function effectively with ICT when fully supported to do so. They recognised that many teachers had not enjoyed the opportunity for professional development, and saw an urgent need for this to be rectified. There were big differences between their teachers in regard to their aptitude for ICT and their use of it. In one school, most of the teachers were seen by their students to find ICT exciting and useful, but this was not the norm. A perceptive student observed the double advantage that accrued to the students who possessed their own laptops *and* were in classes taken by teachers who were enthusiastic about ICT.

> In my school, there is a big difference between teachers who know about the pedagogical use of computers, and the others. Teachers need to learn how to use computers in order to deliver quality in their teaching.
>
> You will always have teachers who want to learn about computers in education and others who do not. In reality it is this which makes the big difference in the classroom.
>
> In some science classes, teachers made little movie presentations to explain concepts like chemical reactions or processes in the human body. In other classes where the teachers were not as well trained, the computer and other equipment sat in a corner getting dusty.
>
> Participants in OECD International Student Network

The students were uniformly agreed on the importance of teacher skill and enthusiasm if the potential of ICT to enhance learning is to be realised. Not surprisingly, they confirm that a well-planned course incorporating ICT needs competence on the part of the teacher in respect of the subject matter – its sequencing and presentation – along with familiarity and fluency in the use of current technology. Teachers in one school had successfully introduced ICT to make for a better-structured learning environment, which was obviously warmly welcomed by the students, as offering a range of useful information and examples of high-quality work:

> Teachers often put educational materials on the homepage, such as essay topics, books to read, and sometimes information about where we can find more data related to specific issues. For example, in history we were asked to choose an essay topic from a list prepared by our teacher. On the teacher's homepage, we could see the books he recommended for use with each topic. Teachers also post on the homepage our essay marks and mid-term test results (...). Sometimes student essays and other work are put on the Internet, when the teacher finds one essay better than the others, so that other students have good examples to follow.
>
> Participant in OECD International Student Network

One student reported an excellently structured biology module, which encouraged co-operative learning, was highly motivating, and left the teacher free to respond to student queries as they arose. The innovative character of the learning method was welcomed by the students, as was the software clarity, ease of use and elements of humour! It had a clear overall objective:

> In our Biology course, to study the nervous system we used software designed by teachers. Guided by a structured brochure (paper), we performed computer exercises from which to deduce the concepts to be learned. The computer brought the usual biology scheme alive, whereby students understood better. The Biology teacher, who was well-informed about informatics, and this software in particular, was available to the class throughout. Students worked in pairs, which encouraged mutual help, both for biology and informatics. The work led to a report given to the teacher a few days later.
>
> Participant in OECD International Student Network

It was observed how much it helps the motivation to learn when the teacher is excited about using ICT, but some teachers admitted during lessons to knowing less that their students, and were not enthusiastic. A student felt this was directly responsible for inattention in class. Many students saw their teachers – the older ones especially – as somewhat afraid of the new technology and therefore resistant to it. There is a policy issue here to be grasped, since more than 70% of the secondary teachers in Germany, Italy, the Netherlands and Sweden are aged over 40 years, and a considerable proportion of these much older (OECD, 2001*a*); for most other countries the problem may not be as severe, but still has to be faced.

One student expressed regret that the computers in the classroom remained unused. In another school, it was estimated that only the teachers of informatics were experienced in using ICT, and even these did not escape the strictures of their students: the lessons were built around out-dated programming languages, that were seen to be neither useful nor enjoyable. In consequence, students associated negative experiences with informatics, and those who were computer-phobic remained unimpressed. Technology advances rapidly, and there will be a continuing need to up-date expertise.

> In the cases where CD-ROMs did not work well in lessons, it was not just the programmes themselves, nor that the students were inexperienced; it was mainly because teachers had no idea about how they were going to use them in the subject. I know it sounds terrible, but that is the way it was most of the time. Students are much more comfortable than teachers in using ICT.
>
> Participant in OECD International Student Network

There was some sympathy for the teachers, in recognition that most at that time had never had specific professional development in this area, but a feeling that this had to change. Moreover, the necessary change was not simply professional development for the teachers, but a radical shift in outlook and motivation.

What role might the more experienced students themselves play in meeting these shortcomings? Those who had used ICT extensively out of school had an advantage over their peers – and often, indeed, over their teachers. Some students thought it important to insist on cooperation between the more and the less skilled: one went so far as to criticise the teachers for not actively pursuing such a policy. Others, however, remained cautious, aware that the skilled students

would need patience, that they risked becoming frustrated and would in any case not necessarily make good teachers. The "computer freaks" might take care of all the ICT work in a group project, but then have no time to do anything else, while the others would never learn to use computers. This would be detrimental for all. In addressing this problem, the students themselves re-staged the arguments that have traditionally been put forward for mixed-ability teaching, or sorting into ability groups.

At least as an interim measure, it may be advantageous for an institution to make use of the exceptional ICT skills possessed by certain of its students, particularly those who show some teaching flair. Perhaps they might be employed as instructors, especially when the institution is open outside normal hours, thereby gaining some modest honorarium. They might welcome this part-time employment – something many students are obliged to seek – that is of direct benefit to their community. The arguments for using such students as instructors within their own educational programme are less clear. Any such innovation would have to be carefully justified, in terms of educational objectives appropriate to themselves.

- *The students in the OECD network give dramatic illustrations of the power of ICT when wisely and imaginatively used to transform the learning environment.*
- *The centrality of the teacher is confirmed by the students, if ICT is to contribute to an effective learning environment. They were clear on the importance of teacher enthusiasm and skills, and familiarity and fluency in the use of current technology, in association with skilful application of ICT within their subject expertise.*
- *The students may use their own ICT expertise to enrich the learning environment, sometimes helping their peers and their teachers, contributing to the development of materials, and in certain circumstances being employed part-time in support of training or maintenance.*

CHAPTER 6

SCHOOLS ORGANISED FOR ICT AND THE HOMES THEY SERVE

In large measure it is teachers who mediate to students the wealth of learning opportunities afforded by ICT. To be effective in fulfilling this role, they need opportunities for professional development on a continuing basis, first to establish sufficient technical competence and familiarity, but then to know how to weave the new techniques into their teaching and learning strategies. None of this, however, is sufficient in itself. The whole ethos of the school must be conducive to the new approaches. The equipment must be available on a suitable scale and fully maintained, with technical and pedagogical support in place.

It is, moreover, in the nature of ICT to facilitate learning beyond the bounds of the school. Self-directed learning with ICT at home or in the community becomes an integral and important aspect of the total learning experience. More than hitherto, there is a dynamic complementarity between learning in school and learning at home. This chapter looks at school organisation and leadership, the support needed and how it may be attained. It considers how ICT-enabled learning at home extends the work in school, and how ICT enhances the relationship between home and school.

SCHOOL ORGANISATION AND LEADERSHIP – A CHANGING CULTURE

Beyond what is commonly acknowledged, the increased emphasis on learner-centred pedagogy and the more open approaches desired in schools – approaches

that are strongly supported by ICT – require a radical systemic change for delivery in a truly effective way. There are in schools, however, deep-rooted structures, attitudes and values, that have been characterised as the grammar of schools (Tyack and Cuban, 1995). This "grammar" arises from received notions of the purpose of education, often deemed to include safeguarding and transmitting the traditions of national culture and identity. It may account for reluctance to readily accept the significant change which the positive adoption of ICT necessitates and brings about.

Despite the strength of these established structures and values, there are forces driving ICT into schools, where it is being enthusiastically embraced. Many education systems anticipate that the adoption of ICT will be a catalyst to achieving a more learner-centred approach. On this view, the technology in schools is not so much the driver of change as the enabler of it. Put another way, some see ICT as a "Trojan Horse" (Papert, 1997) – the means through which fundamental educational change is to be delivered becomes itself the mechanism whereby the change gains acceptance.

It is not that the school must be adapted simply to accommodate ICT, but that ICT more than any other approach can promote the desired emphasis on higher-order skills and processes within student learning. Schools themselves must be learning organisations, capable of responding to and gaining benefit from sustained technological change. There must be a readiness to adapt in the widest sense, for students, teachers, support staff, the whole community involved in the life of the school. But while it is relatively straightforward, assuming resources, to modify the physical infrastructure by putting the new ICT equipment into schools, it is a much more complex process to secure change in practice and aspirations:

> Theoretically, yes [ICT is changing the professional role of teachers]. In practice it will take some time. (...) This principle is preached at all conferences and seminars, stressing that the learner should be in the centre and that we are going to create a new learning environment. Gradually it is being accepted.
>
> Norway (country note)

The extent of the challenge should not be under-estimated. Compared with many other sectors, education has been slow to make changes in organisational practice and culture through the adoption of ICT. The practices in commerce and industry – automobile, textile, retailing, banking – have been transformed to deliver huge gains (though often with considerable tensions during the period

of transition). A comparison was drawn between the working patterns and expectations in schools and those in the digital technology sector and medicine. Schools have customarily placed a relatively low priority on knowledge creation and mediation, on external networking, on innovation as an aspect of their own professional culture; their links with universities and other knowledge organisations are often weak:

> The principal function of educational institutions is the transmission or cultivation of knowledge, skill and understanding in students, but the creation and management of the professional knowledge of the staff, which could potentially enrich and improve teaching and learning, is largely ignored. Moreover, there is a widespread reluctance among educationists to believe that there is much that they might learn from business and industry, and perhaps especially from engineering, to help them in their work.
>
> OECD (2000*b*), p. 70

Within individual schools, the role of leadership is critical. It is essential that the leaders of schools understand the issues surrounding the adoption of ICT, since its thorough integration is likely to demand changes in school timetables and structures, as well as having resource implications. The integrated student-centred activities stimulated by ICT, that promote acquisition of higher-order thinking skills, do not fit well in the short lessons of conventional school timetables. Adjustment may also be needed in classroom layout, in subject boundaries and in teacher responsibilities. Failure to attend concurrently to any of these features may weaken the quality of the ICT-enhanced learning environment. Adapting to the technology will require a whole school approach and a shared vision of the challenges and implications.

> Little attention is as yet being paid – in all sectors of education – to professionalising school managers where the implementation of ICT is concerned (...). At many schools, ICT continues to be seen in isolation. A more professional approach is required on the part of school managers because the literature on innovations shows that the presence of a knowledgeable and fully-committed school head is an important precondition if innovations are to be successful.
>
> Netherlands (2001*a*)

A key part of the school manager's task is to stimulate the sharing of experience between classroom teachers, including how best to harness ICT, in order to generate ideas for improvement within the school. As the Netherlands example above illustrates, however, the role of the principal is crucial but as yet under-developed.

Strategies targeting leadership and system change

Various strategies have aimed to engage school leaders with the new possibilities that ICT offers. In Ireland, it has been recognised that the headteacher is key to ICT being integrated across the curriculum and a specific course is being created to support this role (country note). Norway has a national programme of professional development for school principals, which uses ICT to create a dynamic learning environment across geographical distances. The distributed learning materials include the software systems being developed for school management, normally accompanied by user-training courses and guidelines. The hope is that this methodology will give practical insight into the value of ICT within the delivery of the school curriculum (Norway, country note).

In the United Kingdom, each new headteacher in 1999 (there were 1 200), was provided with a free laptop, as one component in the government's campaign to encourage the use of on-line resources in schools.[1] Teachers reacted very positively, but lacked the experience to take full advantage of them, and the time and opportunity to undertake the necessary training. A major initiative, the National College for School Leadership, was established in 2000, to provide professional qualifications for headteachers, and an on-line community for discussion and debate, with links to esteemed school leaders internationally.[2] The network will allow principals to learn from the experience of others without having to spend time away from their own schools.

Increasingly, principals are using technology in the administrative side of school management and in communication with the education authorities. While this in itself will not lead pedagogical change, it has its own value and can add to a general organisational awareness of ICT's potential. Innovations in curriculum practice and administration advancing together may be mutually supportive:

1. See *http://news.bbc.co.uk/hi/english/education/newsid_481000/481323.stm.*
2. See *http://www.ncslonline.gov.uk/.*

> Just as information technology is changing the learning environment, it is also contributing to improved management and administrative systems and practices in schools (...). Some jurisdictions use software programmes to manage students' school marks, *i.e.* to register students for provincial exams, to administer the exams, and to communicate the results to the schools. Some jurisdictions have provided their teachers with an electronic provincial report card to be used in reporting to parents, as well as an electronic curriculum unit planner. The linking of schools with departments/ministries of education enables documents such as curriculum materials, policy documents, and news releases to be distributed online to schools, and makes them accessible to the general public.
>
> Canada (country note)

Moving beyond individual schools and their leaders, change at the system level may be facilitated by pioneer schools serving as models of good practice. Several national strategies include the development of such schemes. In Ireland, for instance, the Schools Integration Project provided additional funding and support for 361 pilot schools, that became involved in 71 classroom-based action-research projects. Teachers, students and the local community explored how ICT can change the way teachers teach and students learn (Ireland, country note). The extent to which other schools are able to learn from these models is likely to be a key to the long-term success of such programmes.

It is the impact of pilot projects on the broader education system that determines their real value. All too often, lack of attention to dissemination and replication has resulted in isolated and short-term gains. These issues will be illuminated by a forthcoming report based on case studies of some 65 innovatory schools in 23 different countries.[3] The studies examine the different ways that ICT relates to – and acts as a catalyst for – school innovation and improvement. They will uncover the critical variables relating to effective implementation of ICT and look for any undesirable impacts of ICT upon school functioning and student learning.

3. Part of the research into the impact of ICT on learning within the CERI project "ICT and the Quality of Learning".

- *Schools need to become ICT-based learning organisations, with all their members focused on the pursuit of higher-order skills and learning. The deep-rooted structures and values of schools often prove resistant to such radical change, but ICT could be a "Trojan Horse" – the means through which change is delivered being also the way that resistance is overcome.*
- *The central role of school leadership for ensuring the successful adoption of ICT is recognised in various national initiatives. School leaders need a positive understanding of the importance of digital literacy for teachers and students, and of how ICT can enable school improvement.*
- *More work is needed to establish the critical variables relating to the successful adoption and use of ICT in schools, so that good practice can be more widely disseminated. The CERI research into the impact of ICT on learning will make a major contribution to this.*

THE TECHNICAL AND PEDAGOGICAL SUPPORT INFRASTRUCTURE

Once the school is committed to change, once the teachers are conversant with ICT and the computers are in place, a variety of support mechanisms will be needed. It is important for there to be a fully-functional support chain between school leaders, teachers and other professionals. ICT poses pedagogical challenges for teachers, so they will look to the insights of educational researchers and colleagues in regard to the most promising methodology. On the technological side, they may require help to deal with software conflicts, installing new software, network management, setting up Internet access, and sometimes technical failure. In 1994 a US study (Becker, 1994) reported poor levels of support for teachers using ICT. Only 10% of them had access to a person who provided substantial help. Some form of quick-response system that provides in-classroom technical support is essential.

Levels of equipment

At its most basic level, use of ICT will depend on the physical presence of the equipment on a suitable scale. In 1999 the majority of US teachers (80%) felt that lack of time to schedule access was a barrier to use of computers with students (NCES, 2000). Further US evidence suggests that secondary teachers who use ICT are three times as likely to do so on a regular basis if their computers

are in the classroom, with a ratio of at least one computer to four students (Becker *et al.*, 1999). Similarly, teachers with classroom Internet access were four times as likely to have conducted regular e-mail exchanges with other teachers. (CRITO, 1999*b*). The issue of easy access to computers is central to the integration of ICT within the curriculum. These findings are not confined to the US, as a study from Finland indicates:

> An important reason for the low intensity of ICT usage appears to be that computers were usually located in a separate computer laboratory instead of other classrooms where learning and instruction actually happen. Consequently, students and teachers, in many cases, had access to ICT during special ICT courses. Commonly an ICT expert teacher may have taken up 80-90% of computer laboratory time or otherwise controlled access to the computers. In order to facilitate intensive and pedagogically meaningful use of ICT, it is necessary to bring computers into the classrooms.
>
> Hakkarainen *et al.* (2000)

The students in the OECD network also addressed these organisational and resourcing issues. For certain students, there was no problem over equitable access to computers in school. In one case the timetable was designed to ensure that every student had the same opportunities, with supplementary provision made for certain courses such as informatics. The students would typically be encouraged also to use the facilities during intervals between classes and during the lunch break, and in at least one case in the evenings and at weekends. Typically, however, schools are not equipped to provide such individual access to ICT on a point-of-need basis. The reality for many students was less than the ideal, with some classes committed to computer use – media studies, science and technical subjects – and others not. In consequence, the choice of courses in such schools influences whether computers are used on a daily basis or more intermittently.

One reported case illustrates both generous resourcing and unequal access at the same time. Privileged school students in certain classes had their own personal laptop used in all subjects for taking notes and working on assignments. Not surprisingly, they became more confident and capable computer users than their less-equipped peers, while the resulting inequality was a source of disquiet.

> My school started about six years ago with an experimental computer class – which has since become three classes – equipped by the government, a computer company and the national telephone company. I am a student in the latest experimental computer class [that uses computers in every subject in almost every lesson]. Only two schools in the whole country have computer classes. Every student and teacher in these classes has a laptop, used in lessons, but in the ordinary classes students have to pay for their laptops. Our headmaster has doubts about this, because students having to pay for their education is against national policy. For students who do not go to computer classes there is equal access to computers, though at a much lower level.
>
> Participant in OECD International Student Network

The more privileged students were concerned that the educational advantages of ICT should be made readily available to all. They knew that there would always be some differences in the quality and versatility of the home equipment available, as those who could afford to up-date constantly did so. Against this awareness, the students welcomed all moves to make available alternative and compensatory public provision of ICT for learning. In the light of their own experience, the availability and use of ICT has become crucial to effective learning.

Support mechanisms

Many national strategies encourage the designation of one teacher within the school as ICT co-ordinator, to act as the central reference point for ICT issues and to support colleagues on technical and pedagogical issues. Co-ordinators or advisors who are not school-based are frequently former teachers who developed considerable classroom expertise in using ICT. Their promotion both removes innovatory practitioners from teaching, and ensures that the advisors are removed from practice, with no opportunity to go on developing their own methodology. A structure enabling expert teachers to become mentors in support of colleagues, while continuing with a reduced teaching load seems to offer advantages, as in Canada (country note) and Norway (country note). The attention to the professional role of ICT co-ordinator is a potentially fruitful area for development, especially since – through having to respond to contingencies as they arise – the co-ordinator may become unduly preoccupied with technical concerns. In such a situation, the desirable support in respect of the pedagogical implications of ICT will be lost.

Some jurisdictions in Canada are developing other solutions such as training students as technical support staff or bringing in volunteers on call from business or higher education (country note). Elsewhere direct technician support is provided. In Luxembourg, for instance, the Centre de Technologie de l'Éducation provides a pool of technicians who divide their time between schools. France has established a support network operating on different levels:

> The pedagogical and technical support structures foreseen in the national and regional plans for the adoption of ICT in schools are already in place throughout the country. Support teachers have been nominated in each school, and local back-up arrangements are operational at the different administrative levels. Mobile teams and dedicated help lines are available in some cases. Information, advice, examples and debating forums are accessible on the Web sites of institutions and regional education authorities, and on the national Educnet site. The different networks play an increasing role in sharing expertise.
>
> France (country note)

Provision of an ICT co-ordinator or other professional technical support is expensive, so that funding strategies for ICT maintenance and support frequently pose obstacles. Often finance is provided through individual ad hoc grants with no long-term commitment (NCREL, 2000). Somehow, the running costs associated with ICT must be fully incorporated in the annual budget of a school. The UK *Managed Services*[4] scheme, in which schools enter into a contract with an approved supplier, appears to be a move in the direction of regularising this expenditure. Unless capitation is increased, however, savings will have to be found from elsewhere to meet this new charge:

> National Grid for Learning (NGfL) Managed Services simplify and standardise the purchasing and management of ICT equipment and services for schools, colleges and many other educational institutions. They provide complete, integrated packages of products, services and support (...). The advantages of NGfL Managed Services include: full installation, set-up, technical support and training services [so that] teaching and learning professionals are freed from technical issues and concerns (...).
>
> *http://managedservices.ngfl.gov.uk/1/*

4. See *http://managedservices.ngfl.gov.uk.*

In Belgium (French Community), support is incorporated within in-service training days (country note). Sweden publishes a newsletter and magazine, as well as having an interactive Web site (country note). In addition to other technical and pedagogical help, librarian teachers are assigned to Japanese schools as media specialists in order to support teachers and students. Whatever the approaches adopted, it is important for effective help to be available at the time of need. For technical problems, this may necessitate remedial intervention while a lesson is in progress, so the scale of the support services must be equal to this. The pedagogical needs imply a longer-term perspective, but will at the least require time for teachers to plan, and to interact electronically with their peers and others.

The various different support mechanisms are not mutually exclusive. Teachers will want to be in a position to devote regular time to maintain the pursuit of quality in a learning environment greatly influenced by ICT. They will want and need time to keep abreast of related technological and pedagogical advances. Both in respect of the professional role of the teacher and the level of support services that should be available to teachers, the contractual obligations will have to be addressed.

- *Effective use of ICT in schools requires adequate levels of equipment, integrated within each classroom, and readily available elsewhere for student use out of lessons.*
- *A variety of approaches is being implemented to provide systematic ICT support. In some, expert teachers are trained and designated as ICT co-ordinators; other approaches include training students to give technical support and using volunteers from business or higher education.*
- *Without adequate levels of technical support on a rapid-response basis, and continuing pedagogical support, it will not be possible to maintain and develop quality in the ICT-based learning environment.*

ICT AND RELATIONSHIPS BETWEEN THE SCHOOL AND THE HOME

In the pursuit of educational success, the desirability of strong, fruitful links between schools, homes and communities has long been recognised. Moreover, home and social background are known to be among the most powerful factors shaping educational achievement and determining the nature of the educational

provision. Now ICT sharpens the focus on these interrelationships and adds to their importance. The increasing prevalence of home ownership of computers is changing access to knowledge and information, promoting significant learning beyond the programmes, the premises and the hours of formal education, and greatly adding to the possible links between home and school. By the same token, the absence of home ICT facilities is an additional source of disadvantage for some homes and families, a further example of the digital divide.

> The environments in which learning takes place have traditionally been thought of as a set of options between the classroom, the library, the laboratory, the home and the workplace. The arrival of ICT, however, is blurring these distinctions. It enables learning to the place in a variety of different places, both physical and virtual. Learners now have a choice and increasingly wish to combine the options, choosing when and where they study and learn. For education providers, the preparation and integration of materials and services become a challenge since it fundamentally changes and extends the learning environment.
>
> OECD (2001*b*), p. 22

For the most advantaged young people, the computer and the Web are the norm at home. Where schools have moved little to embrace ICT, they may appear uninteresting and sterile to learners who are already familiar with interactive and highly visual media. A commentator spoke of American adolescents living in a world defined by their peers and visiting the alien adult world only during the time spent in their teachers' classrooms (CRITO, 2000). Where, however, ICT use in school and home are complementary, students who have acquired some level of digital literacy at home are advantaged within their formal education setting, being better equipped to use the school ICT facilities effectively.

Extending learning at home

Considerable advantages accrue to students who are able to use ICT at home. At the lowest level, a word processor can enhance their ability to keep notes that are well ordered; they can prepare statistics and graphs with a spreadsheet, and have the ready availability of a spell-check, a dictionary and a thesaurus. Beyond such basic gains, students spoke favourably of working with CD-ROMs at home, as we saw in Chapter 2 (though with reservations about

those designed specifically for the domestic market). In the home environment, however, there may rarely be anyone to take the place of the teacher in providing answers to supplementary questions and in stimulating new approaches. A student observed that there is a limit to what one can learn unaided, but ICT is perfect in support of the structured learning in school.

Further advantages accrue to students with home access to on-line facilities. School Web sites might be re-opened, to find supplementary information and questions, or materials that teachers had selected for their relevance. One school developed its own portal, with a wealth of educational materials and links to other reliable educational sites. Those who used the Internet as a research tool preferred to do so at home, because they had flexibility in their use of time and could pursue their enquiries in their own way. Several students mentioned using e-mail to share problems over homework, or in preparing group projects. One spoke of the added efficiency of working like this, rather than getting a group to meet physically together. The sharing of difficulties with fellow students by electronic networking is mutually beneficial on two counts: either it leads to peer-group solutions or to a clearer articulation of what the problem is, for subsequent discussion with the teacher:

> I use the Internet [to look for] high school or university publications, public or private research institutes, the Websites of teachers and groups of teachers, in practically all curriculum subjects.
> A few weeks ago we had a mathematics exam which we chatted about on the Net (...). I really liked this way of learning (...). It means you are confronted with problems you had not even recognised learning alone (...) and can work at your own pace, which is more relaxing than sitting behind each other in class.
> I am personally disadvantaged not to have Internet at home, since I often need more information, which I cannot get (...). Nowadays being without a computer is like having no hands.
>
> Participants in OECD International Student Network

Many students are no longer allowed to present hand-written essays, and in any case they suspected that teachers viewed computer-presented work more favourably. Students with home access to ICT acknowledged getting better grades, because of the additional information on which they could draw, the facility to extend or change what was first written after further reflection, the help with language and spelling. The students of the OECD International

Student Network were concerned that the educational advantages of ICT should be made readily available to all. They were largely confident that, with decreasing costs, computers would become as common in homes as television, although they recognised that this would take some time, especially in the less-developed countries.

The patterns of learning at home tend to be different from those at school. Partly this reflects practical matters, such as the way family members divided time on shared computers, partly a greater freedom at home as to when and how to work. It may also reflect different emphases and motivations within the learning objectives, making the formal and informal learning domains complementary. One recent study found students working autonomously at home to develop ICT skills in the pursuit of a desired activity, whereas in school it was the skills themselves that formed the objective:

> (...) at home, young people seldom engaged in activities simply with the purpose of learning how to master the technology. When they wanted to learn new skills it was with a purpose in mind that they had chosen – playing a new game, using a new piece of software. Learning new skills, through "fiddling about" and making mistakes was not something that was detached from undertaking the activity itself. Indeed we would suggest that it was the motivation for the activity itself that provided the vital spur for learning. It was by playing the game or using the software that they developed the skills that they needed. (...) What we have called the "conditions for learning", are often very different at home and at school.
>
> Furlong *et al.* (2000)

School-home partnerships

The new ICT learning opportunities are highly motivating for many, and open up dramatic and extended opportunities, but are not in themselves sufficient to ensure learning of quality. The most effective learning environment – whether in a formal or informal setting – remains one based on a carefully managed partnership between the teacher and the taught. For the network students, the availability and use of ICT beyond the classroom have become intrinsic to the provision of an effective learning experience.

Those without home computers might try to compensate by using the school library, where concentration may be difficult and where there is competition for

the available resources. There is a need for resource centres in public libraries and elsewhere to be developed more vigorously as places of learning. Within the schools themselves, the network students wanted the computer facilities to be more readily available out of normal hours. They were sensitive to the real disadvantage of being without home ICT facilities, or of coming from a home where the cultural milieu made it difficult for fruitful learning to occur.

There has always been some tension between formal and informal learning, between the conventions of school and the multitude of less structured learning situations that constantly arise in social and domestic life. ICT is challenging the traditional claim of formal education to superiority over the non-formal. Increasingly with ICT, the learning that takes place at home will become accepted as no less important than that in school, and complementary to it. There must be mutual respect between home and school, as joint contributors to the learning process. To establish this, continuing dialogue – itself made easily possible by ICT – is needed between the two sides.

> (...) the sitting room and classroom will increasingly be required to work in conjunction, although with potentially different objectives and values. The negotiations between these different sites and different lives will require not a fossilisation into opposition that conceptualises one area as the site of authorised knowledge and the other as a potentially disruptive distraction, but an engagement with the different types of learning, forms of expertise, languages and values required within these different arenas.
>
> Facer *et al.* (2001)

The Swedish Färila School project (Dennersten, 1999*a*), initiated in 1996, illustrates in microcosm the need for dialogue between school and community. When the school moved to adopt ICT, it had to educate the parents and enlist their support. The school developed a non-traditional pedagogy, every student and teacher being equipped with a portable computer. In its first two or three years, there were still parents worried about their children not learning anything by heart. ICT and the Internet appeared somewhat strange and frightening. These parents were uncomfortable with the school's new working methods in comparison with what they remembered from their own school days. Dialogue with the parents gained ground, helped by several factors: the interest shown in the school from around the district; the evidence of successful learning; the

information exchange on the students' planning and projects using ICT; the formation of an ICT group for parents.

School Web sites can allow schools and students to make their work available to a wider public outside. They may receive inspiration from others engaged in similar tasks, by the exchange of exemplary models and materials. The public presence of schools on the Web can be enhanced by the use of domain names that identify them as schools. In the UK there was a 75% sign-up rate for the new Internet domain names offered free of charge to all schools in England as part of the School Names on the Net project in 1999.[5] It is anticipated that by 2002 all schools will be using them (UK, country note).

One of the implications of schools adopting the Internet is to make them less-private places, which may help to develop constructive dialogue between schools and between a school and the communities it serves. It allows parents to participate electronically in school activities and more easily to engage in discussion with teachers. The Web provides schools with a publication forum where work can be produced at a very low cost, and yet be accessible both to parents and to a wider audience. Schools and the education service can profit from these possibilities to inform and persuade those whom they seek to serve. Public expectations and professional practice must advance together.

- *The new media are highly motivating for many young people. They provide presentational and research tools, promote student/teacher communications, allow students to create knowledge and interact positively through their own networks.*
- *ICT encourages – and ultimately requires – a rapprochement between formal education and the learning that takes place outside school. The most effective learning environment is one based on a dynamic, carefully managed partnership between home and school, formal and informal, teacher and taught.*
- *The critical relationships between home and school – that reinforce quality learning when they work well – become more important with the advent of ICT, which brings impressive channels of communication between students, teachers, parents and the wider community.*
- *The potential of ICT to enhance the quality of education through home-school partnerships underscores the seriousness of the situation for students who have no home facilities, who are on the wrong side of the "digital divide".*

5. The school domain names take the form schoolname.geographical location.sch.uk.

CHAPTER 7

LOOKING TO THE FUTURE

The current three-year OECD programme "ICT and the Quality of Learning" was launched in 1998, as a major activity within the Centre for Educational Research and Innovation. It arose as a direct response to the interest declared by Ministers of Education in the Member countries. As the programme moves towards its conclusion, therefore, it is entirely fitting to find that the interest of ministers has been strongly maintained and reaffirmed.

A special forum on "ICT and Education" was held at OECD on 2 April 2001, alongside the regular five-yearly meeting of Education Ministers. There was an attendance of some 200, including ministers and senior officials. At the regular meeting (OECD, 2001*c*), the themes within this present report on quality issues were widely endorsed. It was recognised that investment in hardware and software needs to be complemented by investment in the skills of the educators, that teachers must be at the heart of reform, and that their professional development is key. As yet ICT is seen to have been under-exploited in promoting new approaches to improve the quality of teaching and learning.

The forum[1] itself provided lively support for the same themes and some useful supplementary information was supplied by ministers. It appears that all Korean teachers (and disadvantaged students) have been provided with a

1. See "ICT: School Innovation and the Quality of Learning – Progress and Pitfalls", *http://www.oecd.org/cer/*.

computer, and other initiatives have been taken to combat the digital divide. In a partnership with industry, an Icelandic initiative has provided laptops for all secondary students; teachers are changing their methods and home learning is now seen to be crucial. There was recurring emphasis across the meeting on the need for measures to ensure the necessary professional development of teachers, in respect of pedagogy as well as technical skills.

The main input to the forum was a keynote address from Professor Seymour Papert, of the Media Laboratory, Massachusetts Institute of Technology, United States, who himself drew attention to the need for radical changes in education, if the full potential of ICT is to be exploited. He went on to emphasise the *constructional* aspects of learning as well as the *communication* that ICT facilitates. The text of his address is reproduced here in full. It forms a fitting conclusion to the eclectic review attempted in this book. In his own inimitable style, it points us unequivocally to the future.

> "I am very glad to be here. Yesterday for a moment I was not so glad when I was presented with the OECD's document *Education Policy Analysis 2001* (OECD, 2001*d*) because when I opened it I saw that it had already dealt with what I thought was going to be my opening and central point. Fortunately I think that this just gives me the grounds for building on what is in this document for which I really want to congratulate your research organisation. I urge you to consider the document seriously for a number of reasons; one of which is that the world of education is seriously lacking in the attention it gives to developing any sort of vision of the future. There has grown up a tradition of solving the immediate problems that face people right now and producing incremental improvements, but very little effort is given to serious planning, for what the world is going to be like in ten years.
>
> Education planners differ in this respect from modern industry. For example, the papers this weekend were full of news about Boeing's release of their plans for producing an aeroplane that will not even have a test-flight for another ten years. In some spheres of activity people are used to thinking the world is going to change. In education they don't. I think if we want to see radical deep change in education we not only have to break that habit and put effort into thinking about the future, but also understand why this particular culture has developed in the education world. I'm going to elaborate somewhat my theory of that situation.

My theory concerns the system that we have in schools. By system I mean everything from the fact that schools are organised with segregation of ages – first grade, second grade, etc. – and that there is a particular kind of curriculum. The whole lot, content and methodology, is an accurate reflection of the knowledge technologies of the late nineteenth and twentieth centuries. The reason why education reforms in the twentieth century never produced much change was that the system was in equilibrium with the technological infrastructure that existed, and with the needs of the society. So it is not surprising that attempts to change the system did not really work. We now have a radically different kind of technological infrastructure to support learning, and our rapidly evolving society has radically different needs; these are the two themes I am going to develop.

What I like especially about the OECD document is that it does something that is rare: it tries to present six alternative scenarios for the way things might develop. I think it extremely important to keep doing that, and so I am going to step beyond those scenarios and build on them. None of us has a crystal ball to foresee the future, but I think there are some aspects of the future that we can be sure of and some aspects where you can be sufficiently sure for it to be worth exploring in detail and putting real resources into it.

One thing I think certain, which is not reflected adequately in the scenarios here, is that at some point in the future – my guess is in less than ten years – every student, every child from pre-school days will have a personal portable computer. They might not look like the computers we have today, but they will be at least as powerful or even more powerful. That is not a recommendation, not a prediction; it is a statement of fact of what will happen. If you look at it in many different ways, including the trend of cost of this sort of technology and the spread of the technology into society, it is going to be there. Whether it happens in five years or fifteen years might depend on you, but it is going to happen in something like that sort of time. So I think this is something that has to be incorporated in any scenario of the future.

Why is it not emphasised as much as it might be in these scenarios? I suspect because the writers of the scenarios have not had the kind of experience that I have had, which leads me to believe that this kind of technology will radically change the way that people learn what they learn.

This is perhaps the most important point I want to make here today, that generally the education world is misunderstanding the role of these technologies in many different ways. One way is that it thinks in terms of more efficient or better achievement of the same learning goals. I want to try to convince you that it is worth thinking that what children will learn will be very different. This is something to which hardly any attention is being paid and no resources are being devoted; this is something that I think we are going to regret on a worldwide scale.

So now as a little warm up I would like to ask you to consider a parable. Imagine a country that has a highly developed culture: poetry, philosophy, science, mathematics, but nobody has yet learned to write; it just hadn't occurred to them to have pencil and paper or even to write with sticks in the sand. One day somebody develops the idea of written language and the pencil and paper are invented. Very quickly this thing, which becomes known as information and communication technology, ICT for short, is picked up by scientists and by world traders. It has a big impact in those areas, and after awhile somebody wonders why we don't introduce this into our schools. These being cautious people, they decide that it is too risky to give every child one of these new technologies so they put one pencil in every classroom. "If that produces good results", they thought, "we'll maybe produce two pencils in the classroom", and so on.

Well, now we think this is very funny because we know that the role of writing in our culture is much deeper than anything that could develop through one pencil in the classroom, or even six pencils in the classroom. The pencil is deeply embedded in our way of life and thinking from childhood, so it becomes a deep and integral part in the way we think and the way we do everything. I believe that it is absolutely certain, and I invite you to believe that it is sufficiently possible to be taken seriously, that digital technologies will have as important and deep a role as writing, the pencil and paper have had. To develop that role it is no good thinking of putting one computer in every classroom or six computers in every classroom as a step in the right direction: it's no more a step in the right direction than climbing a tree is a step in the right direction towards space travel. In fact it is not only a very tiny step, it is a step in the wrong direction. What our schools are learning to do with this technology is not to use it for radical change in teaching but to use it to support what has already been done in twentieth century learning. In other words, teachers

are being trained, and we spend a lot of money training them, to neutralise this technology, to undo whatever powerful effects it can have, which is a waste, to say the least.

Now, to amplify that thought, which is my main intention here, let me go back to this imaginary country. I notice that these people who were suspicious of putting pencils in large quantities in the hands of children might have had some reasonably good arguments that we don't think of since we think it is funny. Let's take some examples. There was serious opposition to this new-fangled technology, because the thinking was that if children became dependent on writing they would lose their memory power. That serious argument was advanced by Plato. We may know that what you can do with writing more than compensates for that loss. However, for these people who did not know what you could do with writing, it was not at all obvious that the benefits would compensate for the obvious disadvantages.

It was not only memory power, they were suspicious of the idea that this new technology was leading peoples to do mathematics in strange ways that the teachers and parents did not understand. It is impossible to understand that when you think of what you learn in elementary mathematics, it is mostly about written mathematics: when you multiply numbers you write them one under the other and go through a ritual which we were all programmed at school to perform without thinking. Different ways of representing numbers require different algorithms. Very little attaches to how these representations express the mathematical essence. Now the people in the country of the parable did not know anything about that and looked on what we take for granted with great suspicion. We could spin out at great length the various aspects of the written culture that they could not even suspect. For the writing culture to become a powerful thing many inventions had to be made: an encyclopaedia, a dictionary, and so on. I think we are in this situation with the new technologies. The idea that you just dump this new technology there and its power manifests itself is just basically wrong for reasons not really different from those cited by the sceptics in my story. It needs time and resources to develop these different ways of doing things, different ways of learning.

Now, one more parable, this one about professors of education in the middle of the twenty-first century who, looking back at our times, give their students

a question to consider. Why, at the beginning of our century, when the biggest change in learning ever was about to happen, were the important countries in the world taken by a frenzy of preventing that change, by establishing tests and standardised curricula? Many measures – that cast in cultural concrete, so to speak, the knowledge of a previous century – made it much more difficult to explore any development of new kinds of knowledge, new things to learn and ways to learn them.

You can invent many theories to explain this paradox which you will recognise as true to life, especially in my country the United States. Personally I think the real reason is that the proponents of the status quo in education see an end to their way of doing things, so as the last twitch of the dying dragon's tail they close ranks. Whatever the theory adopted one should consider whether certain acts are of a nature to prevent the evolution of powerful educational developments. We don't have to prove that they will have this effect, but the possibility should be factored into the planning.

Coming to less fable-like aspects of understanding and misunderstanding this technology, I want to pick on a semantic point. It's universally called Information Technology to which sometimes the C is added, Information and Communication Technology. There's something very misleading about that, and it's worth digging a little deeply into why that image has taken hold of our imaginations when we think about its use in schools. First of all to have a more general name I am going to use the term *digital technology* to stand for everything that you can do with computers and microcircuits and so on.

When we look around the world, what are the uses, what are the roles of digital technology? One of them, and the one most visible to the general public, is getting on the Internet and getting information. I can find the stock prices, I can get the latest news. It's like television and like the newspaper. It's serving as an information medium. No doubt that's an important part of it, but in the actual world it is not all. In your automobiles, for example, there are microcomputers – there might be six. In the new international space station up there, which I'll refer to again in a little while, are thousands of them. In these big projects digital technology is not there as a source of information, but as a building material. It makes possible the building of things to a complexity that was previously unimaginable. So when we think of digital technology there are two aspects: there is the constructional aspect and the informational aspect.

Now let us look at education. In education also we can distinguish an informational aspect. Of course part of education is giving information to young people, but it's only a small part. Critics of the educational system in the twentieth century even before thinkers like Dewey, Piaget, Vygotsky, thinkers like the contemporary neuro-biologists who are studying the brain, indeed many people who have looked at the problem of learning, find our system at fault. They have recommended a method of learning based more on experience, more on doing projects and less on getting facts and knowing the right answer.

None of these suggestions has actually had a really deep impact on the practice of education. I think an important reason is that there was a lack of an appropriate infrastructure of technology to support their ideas. Dewey could say children should learn by things that should interest them, that are rooted in their own experience, but what if there is no activity of interest in which there are deep mathematics? Are we going to say the child should not learn mathematics? Some people have said that, but obviously that didn't really catch on.

The fact is that with the kinds of things that you could do with mathematics in the twentieth century there were very few which would both resonate with the interests of children and at the same time touch deep mathematical concepts. Of course you can send them out to measure the playground, but this is shallow mathematics and who cares anyway? This is where there is a huge change.

I'm going to give just one example of a kind of activity that I've been engaged with now for thirty years, but recently it has become something that has moved out of the laboratory and is involving maybe a million or so children of the world. This is giving children the opportunity to build robotic devices and to programme them. The Lego Company is producing the latest version that has gone round the world. There is a little computer that is called *MindStorms* that can be programmed by a child and built into a model. The model can then be programmed to do things like walk around, make music and respond to you. I saw some little girls do something that took me completely by surprise, which was to construct something they could dance with. I had never thought of that, maybe not being a little girl. The interesting thing is that I'm talking about seven-year-old, eight-year-old children, who invented a use of this computer that nobody had thought of before.

In certain classes it is girls who are way ahead of the boys in mastering technology and being sophisticated about it. The girls try all sorts of things, but the boys just want to make something fast and strong, so they build straight ahead. It's a change in gender relationships. I'm not saying that doing robotics is the answer. It's just one tiny example of digital technology being used constructively, not as an information medium. It made a real difference to the way in which some people learned and how their teachers saw them, because no one who has seen this any longer believes that girls are less attracted to technological fields or less capable of working in them. This is a deeper use, a deeper impact than the informational aspect.

Now let's step back. In the public view of digital technology there's the informational aspect, Internet, Web..., and there's the constructional aspect, the space station and so on, which most people don't have much to do with. The public view is almost exclusively of the informational side. In education there is also the informational side and the constructional side, but the informational side is the one that fits the conservative idea of what school is about. The constructional side is more radical and involves more change, so it's not surprising that people prefer to focus on the informational side.

Education and the popular view reinforce one another on the informational side of this technology. Our view of what the technology is going to do in education becomes dominated by an informational aspect, which is a dangerously bad thing to do. The real value of this technology is to open up a vast, unprecedented, and up to now unimaginable, range of activities. These both connect with the child's desires – what children love and like to do – and with the deepest ideas of science, culture, history, project management and entrepreneurial thinking and whatever. They are deep ideas of a huge range, and they are the interests of children.

So to round this up, what is the problem with school as we have moved into the twenty-first century? Society is changing with a rapidity that accelerates, but school has changed hardly at all. The gap between school and society increases. This in turn produces a sense among children all over the world that school is not seen as a bridge to the future, but as a bond to the past. I think that the disaffection and the problems with schools everywhere are because of this gap perceived by the children. There is a tendency particularly in the United States to say our schools are getting worse and worse, but they used to be very good, so let's go back to the way

they were. This is a way of aggravating the disease you're trying to cure. We have to find ways to make schools very different.

I've given some examples of how constructional use of the technology can, in principal, turn into powerful experience for children that are rooted in a phenomenon. You can observe worldwide a love affair between children and computers. It's amazing, everywhere in the world. I've worked in countries in Africa and Asia and Central America, and everywhere there is the same response of children to this technology – they love it. We don't have time to go into the reasons, but it is a fact, and if we don't use this fact we are selling our children down the river.

In conclusion I would like to make a few observations about things to do and who is responsible. It would not be right to fail to mention the responsibility of the computer industry. The computer industry has chosen to translate technological advance into more and fancier computer power at approximately the same price level. That technology could have been translated into somebody saying, "OK, we now have enough power to transform learning beyond recognition, let's make it less expensive." If we had wanted to do that, by now, I calculate that the cost per child per year of having a portable personal computer would be somewhere around ten dollars, which any country could afford.

Somebody has got to break that vicious circle. Some country has to decide we are going to create an educationally oriented computer industry. Although there's all the talk about cheaper computers, when you look behind it they want to give an emasculated computer, a purely informational device without any of the powerful constructional aspects. I think that it's a responsibility where the OECD could play a role, and you as ministers of education could play a role to open the door. I don't know who will do it.

Going around many countries I find a curious division. There are developing countries where people really want to see change, but they don't have the resources. Back home in America I find there's complacency. Everybody is complaining about the schools, but they are basically satisfied with the system as it is. They do not really want to see deep change. I don't know who is going to break out of that. Is it a member of the OECD or perhaps one of the partners? I have just come back from Russia, which is an interesting example of what you might call the only developed developing country in the world. I was really struck by how many people

there have given thought both to the foundations of education and the need to find a niche in the industrial world. Somebody is going to break out of this vicious circle, because although human stupidity and reticence and conservatism can continue for a certain length of time eventually it cracks. Eventually when policies are radically out of touch with the needs of the world somebody does something about it. So basically I feel optimistic.

I am going to tell you one last story. Back in the 50s the United States was somewhat embarrassed by the fact that the fastest transatlantic ocean liners belonged to European countries. France and Britain had faster ocean liners than they had, and at the time, of course, crossing the Atlantic was the essence of important travel. Ministers and all important people were into crossing the ocean quickly. So American resources of technology and money were mobilised and led to triumph. They made the fastest boat in the world, the S.S. United States. In the very same year the first commercial jet plane flew and it became totally irrelevant which boat could travel faster across the Atlantic. I'd like you to hold that in your minds when thinking about school. Are we trying to perfect an obsolete system or are we trying to make the educational jet plane?"

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